S H I P YARD D E S I G N
A N D P LANN I N G F O R
A Z O NE O R I E N T E D
P A I N T I N G S Y S T E M

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On behalf of Avondale Shipyards, Inc., Mr. John Peart was the Program Manager responsible for technical direction and publication of the final report.

Program definition and guidance were provided by the members of the Society of Naval Architects and Marine Engineers Ship Production-Committee, Panel 023-1 - Surface Preparation and Coatings.

The material on which the contents are based was compiled by a project team led by Mr. K. Ando, Senior Manager of IHI International, Tokyo, Japan. Team members included Mr. M. Noma, Mr. K. Kobuke and Mr. I. Hirota, of IHI Kure shipyard.

Mr. Y. Ichinose, President of IHI Marine Technology, functioned as project manager and was responsible for the coordination of the work undertaken by IHI. The work was significantly rewritten, supplemented and reorganized by Mr. J.W. Peart and Ms. Linda L. Jaekel.

FOREWORD

Previous National Shipbuilding Research Program investigations (1, 2) have described the logic and methods employed by the Japanese shipbuilder to maintain high productivity and still provide a coating system of respectable quality.

This study provides additional information to further develop the coating designer/planner knowledge and skills to better implement the transition from system to zone logic.

The organization of management and work described herein are based upon the effective methods developed by Ishikawajima-Harima Heavy Industries Company, Ltd. (IHI)

1/ "A Descriptive Overview of Japanese Shipbuilding Surface Preparation and Coating Methods", J. Peart and G. Soltz, National Shipbuilding Research Program, September 1982.

2/ "Zone Painting Method", J. Peart and H. Kurose, National Shipbuilding Research Program, August 1983.

EXECUTIVE SUMMARY

Shipbuilding is a multi-faceted industry, requiring the coordination of many activities and relying on ever evolving technology. Painting is an integral, and costly, part of this operation.

This paper describes the Zone Painting Method; a new concept in ship construction which is based on the Product Work Breakdown Structure. The essence of the Zone Painting Method is proper planning and scheduling, in coordination with hull construction and outfitting.

Design and planning structures, as related to zone painting, are presented. Departmental responsibilities for those segments of the shipyard organization which impact painting are detailed. The paper then proceeds to delineate the planning process according to the three phases of contract planning, system planning and zone planning. These phases examine the painting process in ever-increasing detail.

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

The Zone Painting Method (ZPTM) is a cost-effective and productive method of paint application, based on good planning and scheduling. Integrated with the Hull Block Construction Method (HBCM) 1/ and the Zone Outfitting Method (ZOFM) 2/ , ZPTM'S purpose is to paint as much as possible prior *to* launch. All three methods are based on the Product Work Breakdown Structure (PWBS) 3/ , a structure which sub-divides ship construction into the needed parts and subassemblies.

The scope of this paper is to describe the design and planning requirements for the Zone Painting Method. Section 2 describes the organization structure and departmental responsibilities, and section 3 delineates the planning process according to the paint design stages of contract planning, system planning and zone planning.

As the Zone Painting Method is integrated with the Hull Block Construction Method and the Zone Outfitting Method, a list of references describing these methods is provided in the back of this document to help the reader.

1/ For a detailed description, please refer to "Product Work Breakdown Structure" Y. Okayama and L.D. Chirillo, National Shipbuilding Research Program; November 1980.

2/ IBID

3/ IBID

2.0 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES

The Zone Painting Method (ZPTM) is divided into two stages; the design stage and the production stage. The Ship Design Department has the paint planning responsibility in the design stage while the Painting Department is responsible for production. Coordination is required not only between the Ship Design Department and the Painting Department (production), but with the Hull Construction Department, the Outfitting Department, Purchasing, and any other department which impacts paint design and production. Figure 2-1, Shipyard Organization, shows the placement of these departments within the shipyard structure.

In the design process, these shipyard organizations have certain responsibilities in accordance with the particular planning phase. These three phases are contract planning system planning and zone planning.

In the contract planning phase, the Basic Design Department prepares a tentative paint scheme and paint budget estimate. These preliminary plans are then negotiated with the owner to better reflect the owner's requirements and practices. The paint scheme and costs are then finalized with the owner.

Most paint specifications are defined during the contract planning phase by the Basic Design Department. These people must know not only the theory of painting, but also painting methods at the shipyard. They maintain communications with members of the Paint Design Group, the Painting Department and paint manufacturers representatives in order to remain aware of all the latest data on paint materials and application methods.

Once the contract is signed, the Key Planning Section within the Paint Design Group develops the system planning. This phase

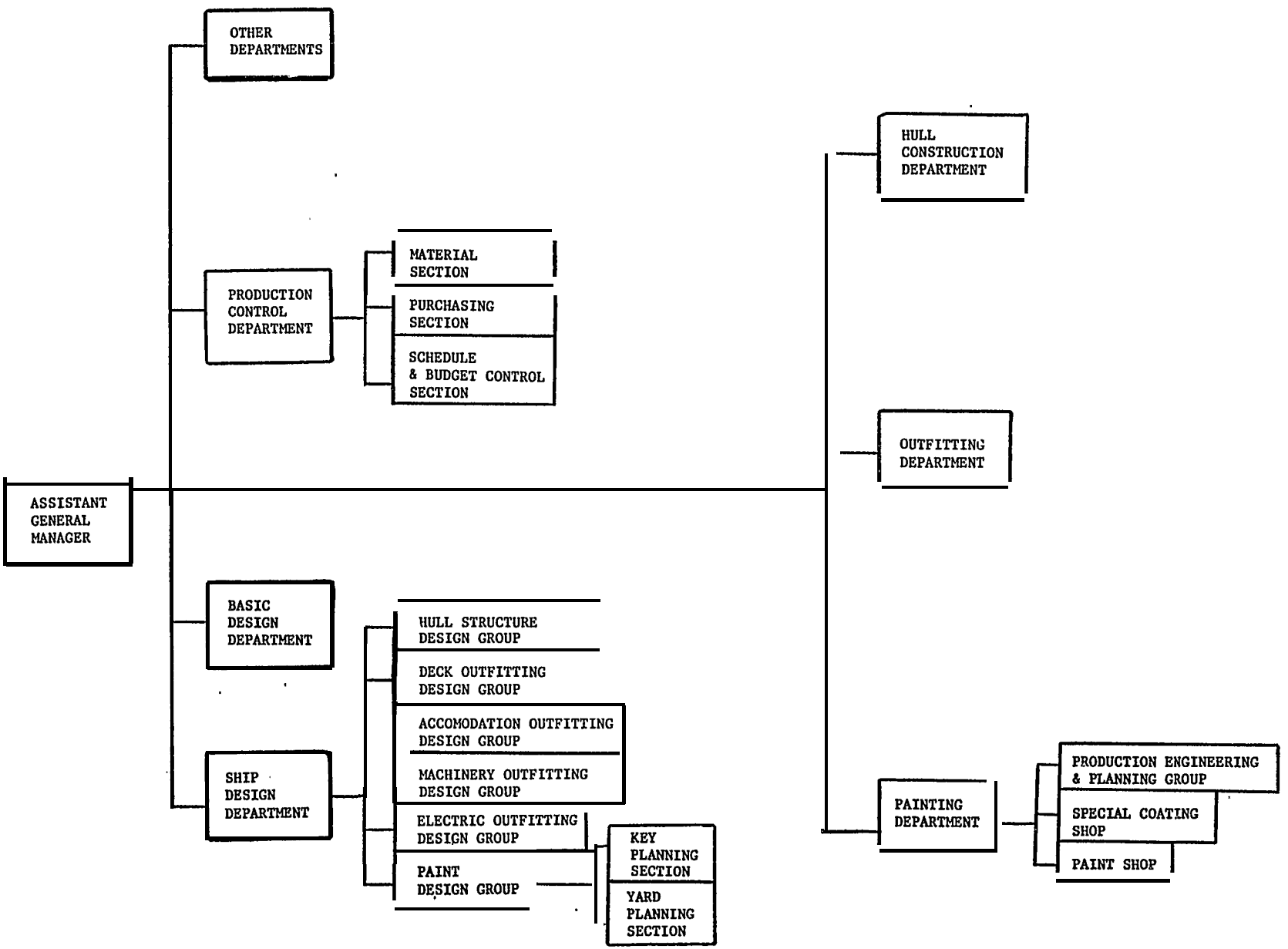


Figure 2-1 Shipyard Organization

includes preparing the paint specifications and materials list requirements . Subsequently, the Paint Department prepares the paint master plan (outlining paint procedures and methods), the paint master schedule and the pallet list (all information and resources needed for a work unit, defined as zone/area/stage).

Zone planning for painting is carried out by the Yard Planning Section of the Paint Design Group. Each zone is planned in accordance with the paint specifications, the paint master plan, the paint master schedule, and the pallet list. In shipyards which have adopted the ZPTM, much of the painting is performed at the part and assembly level, and are then palletized. A transition phase from a system orientation (paint specifications) to a zone orientation (work instruction drawings) is necessary. This requires the preparation of instruction drawings for each pallet.

The following units of this section will discuss the responsibilities of the Paint Design Group and the Painting Department as well as the interaction and coordination of these and other related shipyard departments.

2.1 PAINT DESIGN GROUP

The Paint Design Group is smaller than the other groups in the Ship Design Department due to a more limited scope of work. Each group is organized according to the

- specific job nature,
- production requirements, and
- the scope of each manager’s responsibility.

The Paint Design Group may exist independently, may be merged with other functions in a special design group, or may be combined with another existing design group (such as the Hull Structure Design Group). An independent Paint Design Group is

preferable for coordinating activities with the other design groups and production departments because it is difficult to manage a group with mixed responsibilities.

Responsibilities of the Paint Design Group are:

(1) (System Planning) defining paint specifications for surface preparation requirements, the type of paint to be applied, compartment areas to be painted and the number of paint coats, and

(2) (Zone planning) producing the work instruction drawings and information for each pallet, using the system oriented paint specifications.

The Paint Design Group is divided into two units; the Key Planning Section which is responsible for system planning and the Yard Planning Section which is responsible for zone planning. Specific activities for these two units are listed below.

Key Planning Section - Activities

1. Write paint specifications.
2. Produce the paint materials list by system (MLS).
3. Update the Budget Control List (prepared in the contract planning phase) for the required volume of paint material according to the MLS. The required volume of paint material is updated during each planning phase.
4. Prepare *cost* estimates for specification changes.

Yard Planning Section - Activities

1. Plan the transition tables from a system to a zone orientation (see Figures 3-17 and 3-18).
2. Produce on-block and on-board paint work tables, by pallet, for hull construction.
3. Produce paint specifications for outfitting components and an on-board paint work table, by pallet, for outfitting.

4. Develop a list of paint materials by pallet (i.e. for fittings) (MLF).
5. Update the Budget Control List for the required volume of paint material according to the MLF.

Members of the Yard Planning Section need to be familiar with the following items in order to produce zone-oriented information and work instruction drawings.

- How to paint according to the paint master plan.
- Time and place to paint according to the paint master schedule.
- How to organize the painting by pallets according to the pallet list.

The functions of these sections within the Paint Design Group are indicated in Figure 2-2, Paint Design and Planning Process Chart.

2.2 Painting Department

The Painting Department (production), like the Paint Design Group, is relatively smaller than the Hull Construction Department or the Outfitting Department. Some shipyards may combine painting with one of these other departments due to the smaller size, but paint design and application remain independent functions necessary to ship production.

Another possibility is for the Painting Department to incorporate the functions of the Paint Design Group in preparing paint specifications and work instruction drawings. This structure is possible because:

- the Painting Department can develop paint planning using the paint scheme prepared by the Basic Design Department;
- there are many planning items which relate heavily to production-oriented matters (such as coating methods and stages); and

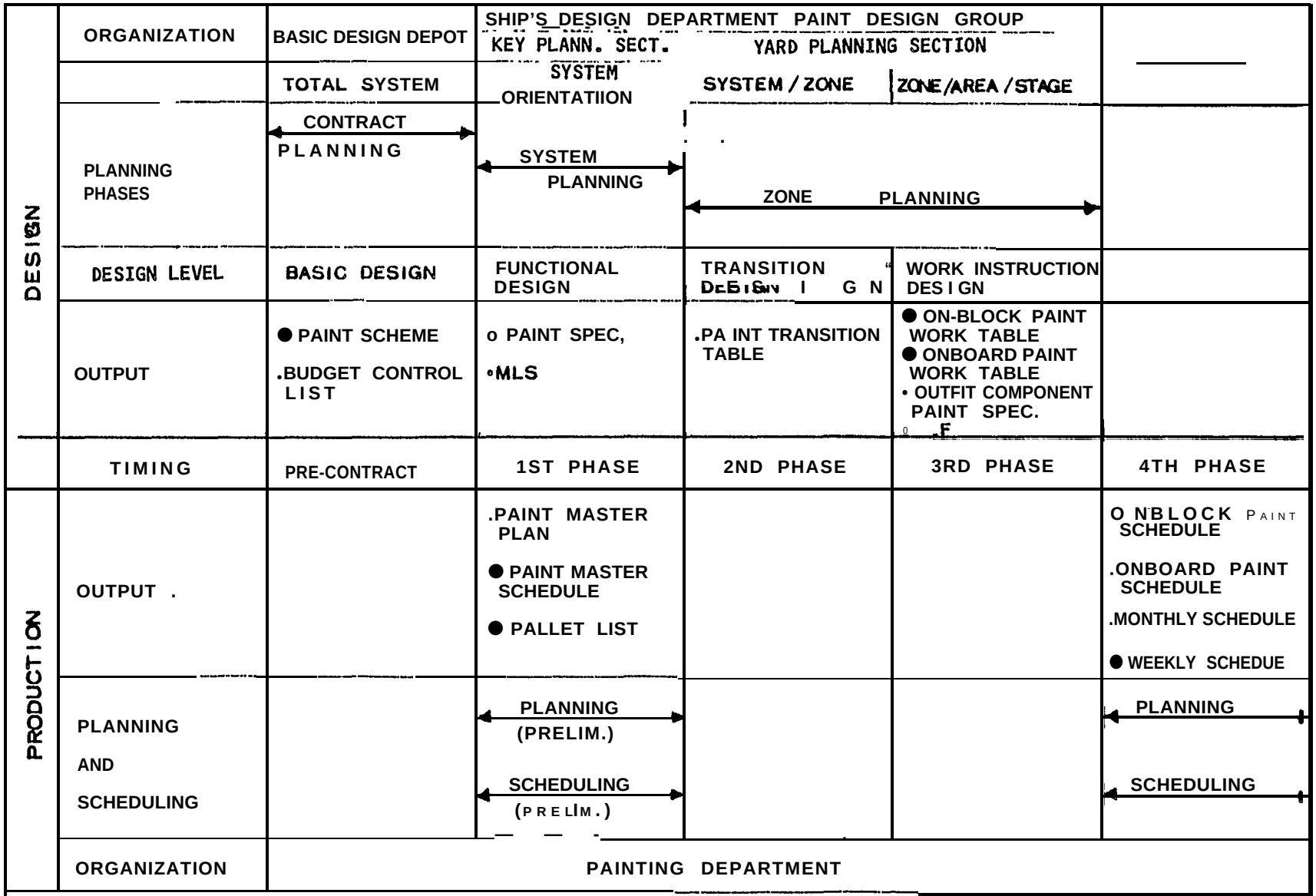


Figure 2-2 : Paint Design and Planning Process Chart.

- 0 paint planning and paint work can be easily managed together.

Under a combined system, detailed planning (except the system planning) is done by the Painting Department. Activities of this department, as distinct from the Paint Design Group, are listed below.

Painting Department - Activities

1. Develop a paint master plan.
2. Develop a paint master schedule.
3. Develop a pallet list.
4. Produce detailed schedules for on-block painting, on-board painting, and monthly, weekly and daily schedules.
5. Determine labor requirements.
6. Determine material requirements.
7. Determine paint quality.
8. Determine safety requirements.
9. Determine paint work to be subcontracted.
10. Work with paint manufacturer to determine painting application requirements and improvement of paint materials.

Figure 2-2, Paint Design and Planning Process Chart, shows the timing of the first five activities listed above.

2.3 Coordination

The Paint Design Group must communicate with and coordinate its activities with other shipyard organizations. The Paint Design Group provides the following information.

1. Paint specifications and work instruction drawings to the Painting Department.
2. A materials list to Purchasing.
3. Paint specifications to other design groups.

The Paint Design Group receives the following information.

1. A paint master plan, a paint master schedule and pallet lists from the Painting Department.
2. Materials list issuing dates from Purchasing.
3. Key plans and yard plans from other design groups. This includes:
   a. paint. specifications (type of paint, number of coats, color scheme and so on) for pipes and individual outfit components, including auxiliary machinery, from the outfitting design groups; and
   b. shop primer specifications for steel plates coated with shop primer outside the shipyard, from the Hull Structure Design Group.

Specific production schedules are prepared by each department in accordance with the shipyard master schedule, necessitating the coordination of each department's schedule. The combined schedule for hull construction, outfitting and painting is called the Integrated Hull Construction, Outfitting and Painting (IHOP) Schedule.

Figure 2-3 shows the inter-relationships between the Paint Design Group and other departments. The introduction of ZOFM and ZPTM into shipyard production processes by on-unit, on-block and on-board stages requires the coordination of scheduling and tracking operations among the production departments and design groups. Design and production people in each department or group must plan the IHOP schedule for each ship.

This integrated schedule is prepared by coordinating the hull construction, outfitting and paint schedules based on each hull block in the hull block erection schedule. It defines activities for each period by hull block, as shown in the sample IHOP schedule (Figure 2-4).

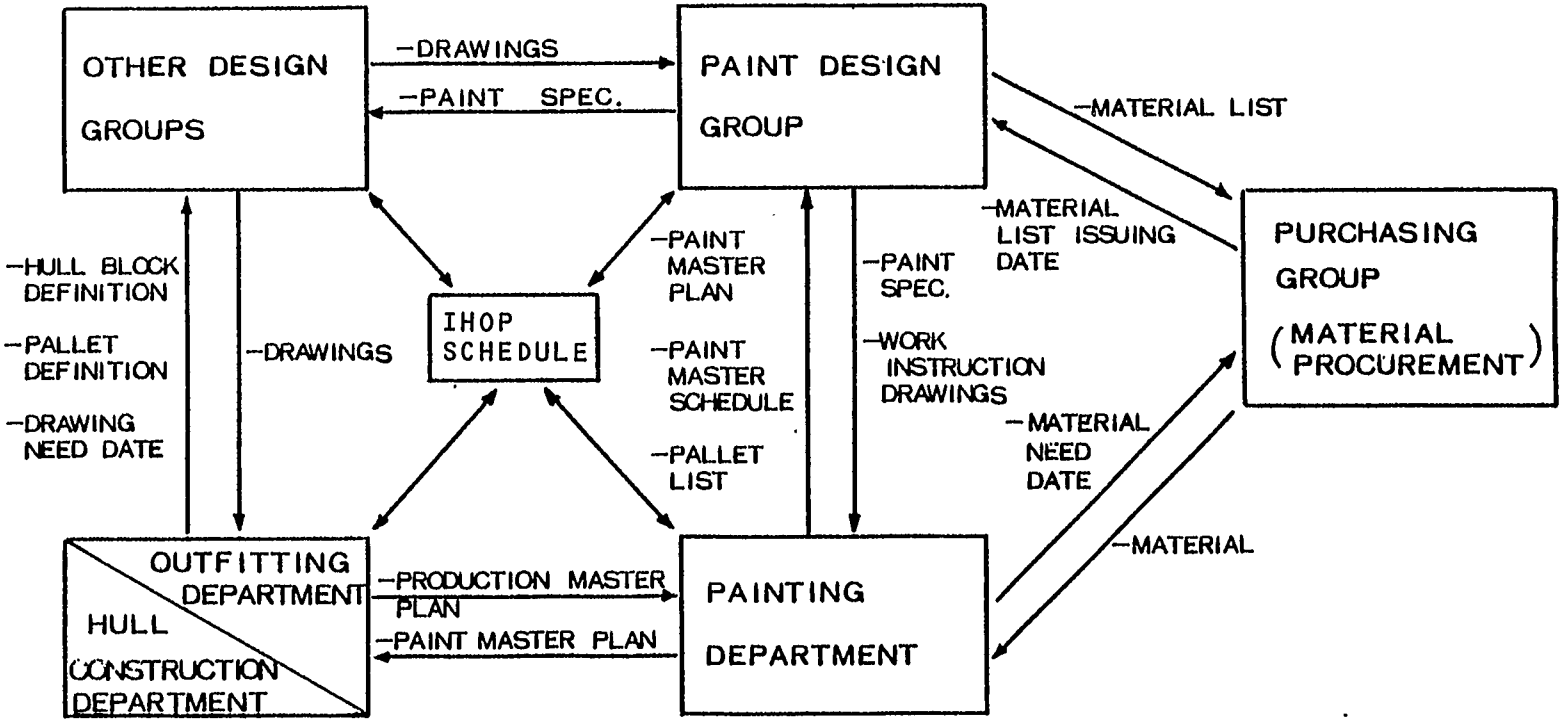
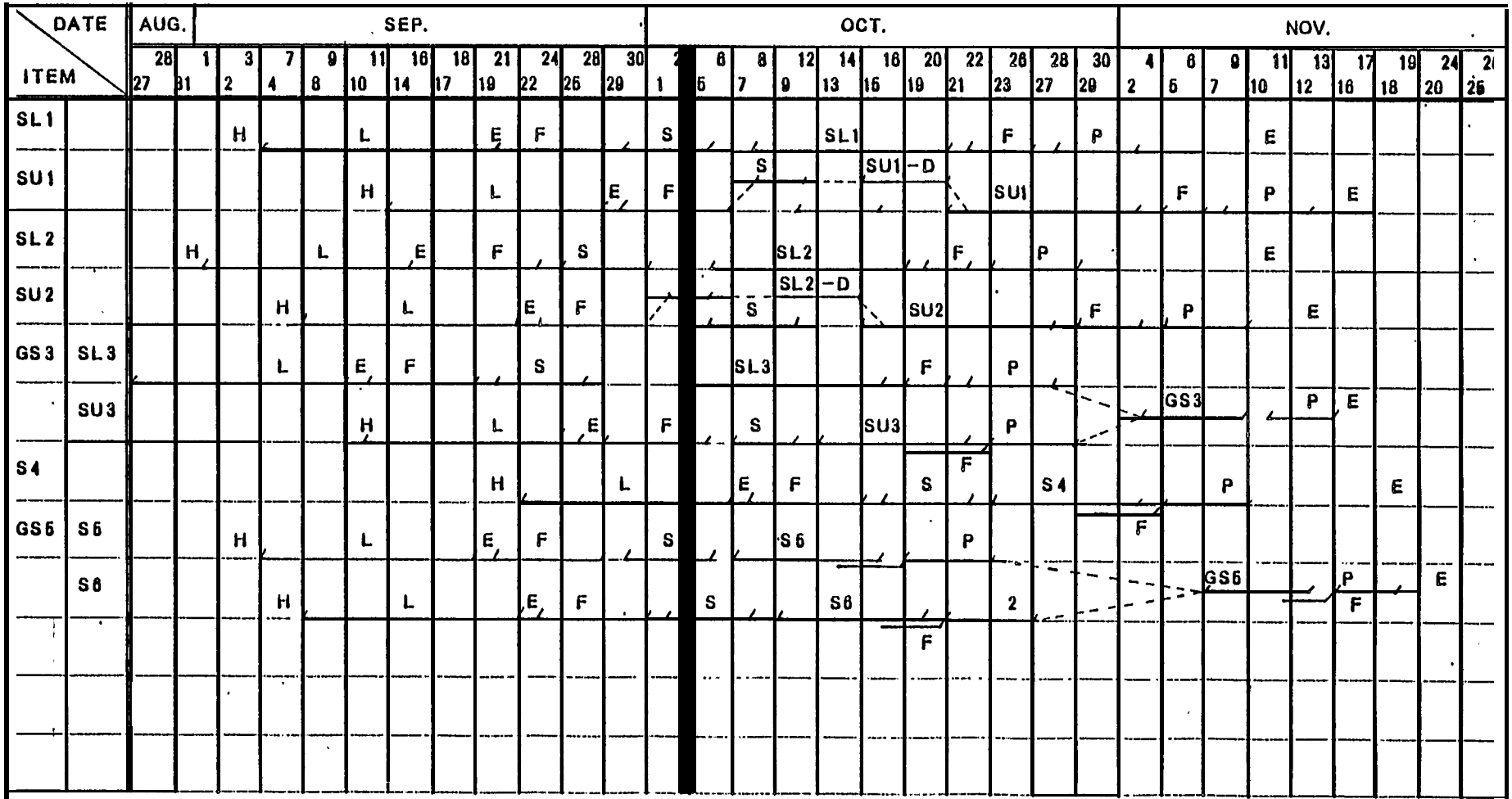


Figure 2-3 : Interdepartmental Relationships



NOTES : H : ISSUE OF DRAWINGS + YARD PLANS
L : MOLD LOFT
E : E. P. M
F : FABRICATION
S : SUB-ASSEMBLY
F : FITTING
P : PAINTING
E : ERECTION

Figure 2-4 : An Integrated Hull Construction, Outfitting and Painting (IHOP) Schedule

3.0 PLANNING PROCESS

Currently, the period between signing the contract and ship delivery must be shorter than in the past due to the market constraints of lower demand. Therefore, material should be ordered with an adequate lead time, obtained by working backwards from the material requirement date. Specifications and paint material lists need to be prepared by the paint group in advance of ordering the materials. Thus, the design period becomes shortened.

If design and planning were to start from scratch each time, it would be impossible to complete the drawings and plans under severe time constraints. Shipyards have experience in ship design for various types of ships and many of these drawings and plans can be used for the design and planning of other ships. The standardization and modularization of these designs can be employed to reduce the design man-hours and shorten the design schedule period.

For the painting aspects, shipyards generally depend upon the input of paint manufacturers, who are continually developing and improving upon paint material and painting methods. The shipyard paint engineers should always collect information from the manufacturers for updating the standard paint drawings and practices to be ready for use in succeeding ship construction. This updated data is utilized to prepare cost-effective surface preparation and coating standards and specifications. This reduces coating and production costs and provides the shipyard a favorable position during its contract negotiations with the owner. The three planning phases in new ship construction (contract planning, system planning and zone planning) will be presented in the following sections of this unit.

3.1 PRE-CONTRACT AND CONTRACT PLANNING

Pre-contract and contract planning are conducted by the Basic Design Department before signing the contract. Upon initiating a new ship project, a tentative paint scheme (such as in Figure 3-1) is prepared and presented to the owner with other outline specifications such as ships dimension, main engine capacity, cargo space capacity and so on. This tentative paint scheme is chosen from several shipyard standard paint schemes depending upon type of ship and service route. This shipyard standard has been proven to be compatible with the shipyards construction method and provides the lowest production costs for the shipyard. Figure 3-2 shows a standard paint scheme utilizing chlorinated rubber paint. The scheme delineates only the typical compartments or areas to be painted, paint film thickness, grade of surface preparation, etc. These choices are based upon paint tables such as in Figures 3-3 and 3-4, as quoted from the "Shipbuilding Handbook", edited by the Society of Naval Architects of Kansai, Japan. These tables describe the resistance of the paint systems to the applicable environments and the compatibility of the different coatings in the system.

In the next stage, the final paint scheme reflects changes to the tentative scheme required by the owner. Requirements often requested by the owner are:

- Higher grade of surface preparation,
- Increased number of paint coats,
- Increased paint film thickness,
- Designation of a specific paint manufacturer, and
- Application of a high grade paint system.
- Coating of tanks after erection rather than on block.

Some owners may request the application of a special coating; for example, in the tank of an oil carrier. These special applications should be studied and resolved with the shipyard

Surface preparation

Surfaces of steel plates and structurals shall be coated with one (1) coat of inorganic zinc primer after shot blasting.

Coating	# coats
Bottom shell	2-CRAC (Min. 150 Mic.)
	2-CRAF
Boot top shell	2-CRAC (Min. 150 Mic.)
	2-CRBT
Top side shell	2-CRAC (Min. 75 Mic.)
	2-CRTS
Exposed weather deck	2-CRRP
	2-CRDP
Cargo hold	2-CRRP
	1-CRHP
Ballast water tank	1-TE (Min. 180 Mic.)
Fresh water tank	2-PE

CR = Chlorinated Rubber
AC = Anti-Corrosive
AF= Anti-Fouling
BT = Boot Top Paint
TS = Top Side Paint
RP= Primer Paint
DP = Deck Paint
HP= Hold Paint
TE = Tar Epoxy Paint
PE = Pure Epoxy Paint

Figure 3-1 Tentative Paint Scheme

CRAC = Chlorinated Rubber Anti-Corrosive
CRAF = Chlorinated Rubber Anti-Fouling
CRBT = Chlorinated Rubber Boot Top Paint
CRDP = Chlorinated Rubber Deck Paint
CRFC = Chlorinated Rubber Finish Paint
CRRP = Chlorinated Rubber Primer Paint
CRTS = Chlorinated Rubber Top Side Paint

S!$if%i!!%sl 25 microns = 1 mil paint film thickness

Finish Paint
Non-Zinc Epoxy Primer
Pure Epoxy Paint
Primer Paint
Tar Epoxy Paint
Wash Primer
Zinc Epoxy Primer

ITEM / PAINTING AREA		PAINT SPECIFICATION		1ST SURFACE PREP.		2ND SURFACE PREP.	
		KIND OF PAINT AND LAYER	DRY FILM (MICR)	TREATMENT	SHOP PRIMER	TREATMENT	REMEDY FOR SHOP PRIMER
SHELL	BOTTOM	CRAC × 2 CRAF × 2	140 80	SHOP BLAST	WP, OR ZP, OR NZP	POWER TOOL	YES
	BOOT TOP	CRAC × 2 CRBT × 2	140 60	DO	DO	DO	DO
	TOP SIDE	CRAC × 2 CRTS × 2	140 60	DO	DO	DO	NO
EXPOSED PART	EXPOSED DECK	CRRP × 2 CRDP × 1	70 35	DO	DO	DO	DO
	SUPERSTRUCTURE	CRRP × 2 CRFC × 2	70 60	DO	DO	DO	DO
ENGINE ROOM	TANK TOP	TE × 1	100	DO	DO	DO	DO
	OTHER	OIL RP × 2 OIL FC × 1	70 35	DO	DO	DO	DO
PUMP ROOM	LOWER PART	TE × 1	100	DO	DO	DO	DO
	OTHER	OIL RP × 2 OIL FC × 1	70 35	DO	DO	DO	DO
INSIDE OF SUPERSTRUC.	BARE STEEL	OIL RP × 2 OIL FC × 1	70 35	DO	DO	DO	DO
	UNDER LINING	OIL RP × 2	70	DO	DO	DO	DO
TANK	CARGO OIL TANK	NON	—	—	—	—	—
	BALLAST W. TANK	TE × 1	250	SHOP BLAST	WP, OR ZP, OR NZP	POWER TOOL	NO
	CARGO OIL/ BALLAST W. TANK	TE × 1	250	DO	DO	DO	DO
	FUEL OIL TANK	NON	—	DO	DO	OIL WIPE	DO
	FRESH WATER TANK	PE × 2	150	DO	DO	POWER TOOL	DO
	COFFERDAM AND VOID SPACE	OIL RP × 2	70	DO	DO	DO	DO

Figure 3-2 : Standard Paint Scheme

	EASE OF WORK	DRYNESS	WEATHER-PROOF	WATERPROOF	MEDICINE-PROOF
OIL PAINT	o	A	A	A	X
PHENOL RESIN PAINT	o	0	0	0	0
ALKYD RESIN PAINT	o	0	0	°	°
VINYL RESIN PAINT	o	0	0	0	o
CHLORINATED RUBBER PAINT	o	O	o	o	o
EPOXY RESIN PAINT	A	o	0	0	0

ORDER OF ADVANTAGE : ◎ → ○ → △ → ×

Figure 3-3 : Paint Data Table.

	OIL PAINT	CHLORINATED RUBBER PAINT	VINYL PAINT	TAR-EPOXY PAINT	PURE-EPOXY PAINT	INORG. ZINC PAINT
WASH PRIMER	O	O	O	O	△	×
NON ZINC EPOXY PRIMER	O	O	O	O	O	×
ZINC EPOXY PRIMER	△	O	O	O	O	×
INORGANIC ZINC PRIMER	×	△	O	O	O	O

O : Suitable

△ : Check if painting conditions are permissible within the limitations of the paint brand

× : Not suitable

Figure 3-4 : Paint/Shop Primer Table

engineer and paint manufacturer during the contract planning phase.

These changes in the shipyard standard schemes often have a negative productivity impact on the shipyard, which results in additional coating cost for the owner. These additional costs are usually quite high, which often leads the owner to opt for the original shipyard standards.

The coating specification covers the following items:

- Compartments or areas to be painted,
- Grade of surface preparation,
- Kinds of shop primer,
- Kinds of paint,
- Number of coats, and
- Paint film thickness.

Some typical paint schemes for the hull structure and outfit components are shown in Figures 3-5 and 3-6. The specification scheme, which has been negotiated with the owner, is finalized as the contract specification.

The surface preparation of steel is crucial to painting because inadequate surface preparation often results in bad paint performance. Surface preparation, therefore, should be discussed and clarified in detail with the owner during the paint scheme negotiations. The following surface preparation standards are most commonly used in the shipbuilding industry:

- Swedish Standards Institution, "SIS 05 59 00 - 1967: Pictorial Surface Preparation Standards for painting Steel Surfaces".
- Steel Structures Painting Council, Surface preparation Standards, 1963.
- Individual country standards.

The above standards, while recognized as good ones for surface preparation, do not cover removal of welding beads, treatment of burnt surfaces by gas cutting and arc welding, and general rework

PAINTING AREA			GRADE OF SURFACE PREPARATION [1]		SHOP PRIMER [2]	PAINT + NUMBER OF COATS [3]					REMARKS
			BEFORE SHOP PRIMER	BEFORE FIRST COATING		1	2	3	4	5	
EXTERIOR PART	SHELL	BOTTOM	SP-10	SP-3	IZP	CRAC	CRAC	CRAF	CRAF		CRAC - MIN THICKNESS 150 MIC. IN TOTAL
		BOOT TOP	SP-10	SP-3	IZP	CRAC	CRAC	CRBT	CRBT		CRAC - MIN THICKNESS 150 MIC. IN TOTAL
		TOP SIDE	SP-10	SP-3	IZP	CRAC	CRAC	CRTS	CRTS		CRAC - MIN THICKNESS 75 MIC. IN TOTAL
	DECK AND SUPERSTRUCTURE	DECK	SP-10	SP-3	IZP	CRRP	CRRP	CRDP	CRDP		
		DECK HOUSE	SP-10	SP-3	IZP	CRRP	CRRP	CRUC	CRFC		
INTERIOR PART	CARGO HOLD	CEILING	SP-10	SP-3	IZP	CRRP	CRRP	CRHP			
		BOTTOM	SP-10	SP-3	IZP	CRRP	CRRP	CRHP			
		BILGE WELL	SP-10	SP-3	IZP	TE					
	ENGINE ROOM	CEILING	SP-10	SP-3	IZP	LZ	WR	FC			
		TANK TOP	SP-10	SP-3	IZP	TE					
		FLOOR	SP-10	SP-3	IZP	LZ	LZ	DP			

[1] Steel Structures Painting Council (SSPC) Surface Preparation Specifications
SP-10 "Near White Blast Cleaning"
SP-3 "Power Tool Cleaning"

[2] IZP = Inorganic Zinc Primer

[3] CRAC = Chlorinated Rubber Anti-Corrosive
CRAF = Chlorinated Rubber Anti-Fouling
CRBT = Chlorinated Rubber Boot Top Paint
CRBT = Chlorinated Rubber Finish Paint
CRHP = Chlorinated Rubber Hold Paint
CRRP = Chlorinated Rubber Primer Paint
CRTS = Chlorinated Rubber Top Side Paint
DP = Deck Paint
FC = Finish Paint
LZ = Lead Zinc Chromate Primer
TE = Tar Epoxy Paint
WR = White Rust Resisting Paint

Figure 3-5 : Hull Structure Paint Scheme.
This paint scheme is included in the contract specifications.

PAINTING AREA				GRADE OF SURFACE PREPARATION		SHOP PRIMER	PAINT + NUMBER OF COATS					REMARKS
				BEFORE SHOP PRIMER	BEFORE SHOP COATING		1	2	3	4	5	
INTERIOR PART	ENGINE ROOM	MACHINERY EQUIPMENT	MAIN ENGINE	–	SP-2	–	LZ	FC	FC			
			AUX. BOILER	–	SP-2	–	HR	HR				
			AUX. MACHINERIES	–	–	–	MANUFACTURER'S STANDARD					
		TANK	FUEL OIL TANK	SP-10	–	IZP	NO COATING					
			LUB OIL TANK	SP-10	SP-3	IZP	WIPED WITH OIL					
			FRESH WATER TANK	SP-10	SP-3	IZP	PE	PE				
			BALLAST WATER TANK	SP-10	SP-3	IZP	TE					MIN. 180 MIC
		–	–	–	–	–	–	–				
		–	–	–	–	–	–	–				
		–	–	–	–	–	–	–				
		–	–	–	–	–						

PAINT + NUMBER OF COATS

[1] Steel Structures Painting Council (SSPC) Surface Preparation Specifications
SP-10 = "Near White Blast Cleaning"
SP-2 = "Hand Tool Cleaning"
SP-3 = "Power Tool Cleaning"

[2] IZP = Inorganic Zinc Primer

[3] FC = Finish Paint
HR = Heat Resistant Paint
LZ = Lead Zinc Chromate Primer
PE = Pure Epoxy Paint
TE = Tar Epoxy Paint

Figure 3-6 : Outfitting Components Paint Scheme

This paint scheme is included in the contract specifications.

items. Ishikawajima-Harima Heavy Industries Co., Ltd. has a published steel surface preparation standard which cover these items.

Trouble sometimes occurs in painting performance during construction and/or after delivery of a ship, and the cost of repair can become quite expensive. Damage is rarely limited to one spot but usually extends to a large area, so the repair can require dry-docking, scaffolding, abrasive blasting and so on. Coating re-work has an extreme negative impact on production, schedule and cost as well as guarantee costs. Therefore, careful attention to painting is essential in the planning phase.

The final paint scheme should be reviewed in detail with the Design Department, Painting Department and paint material manufacturer in the planning phase.

All material and application specification documentation is maintained by the Basic Design Department. Therefore, the basic designer must communicate with the detail design engineers, Painting Department and paint manufacturer. Many times, a Paint Technical Committee is established for information exchange.

This committee is composed of people from the Basic Design Department, the Paint Design Group, the Paint Department and paint manufacturers representatives. A manager is generally appointed chairman and he will call meetings on subjects such as the following:

- Standardization of drawings for paint schemes and specifications.
- Standardization of painting practices and procedures.
- Technical study of new types of paint for ship applications.
- Failure investigation and analysis of damaged and defective paint materials from reports on delivered ships and ships under construction.

The last job in the contract planning phase is to estimate the paint material requirements and to prepare the budget control list for painting.

The paint material requirements are calculated and refined at each planning phase:

- first; system by system, in weight (kg), by paint area from cost estimation charts of the whole ship during contract planning;
- secondly; system by system, in weight (kg), by paint area from key plans during system planning, and
- finally; pallet by pallet, by volume from the number of cans required for each paint area from the final pallet list definition of material requirements during zone planning.

The calculations of material requirements become more accurate at each stage, with the most accurate calculation being determined at the pallet stage.

At the contract planning phase, paint material volume is calculated from the following formula:

$W = K \times A$

- W: Paint required (in grams).
- K: Coefficient (in gram per sq.m. per coat) as obtained from Figure 3-7.
- A: Area to be painted (in sq.m.) as obtained from Figures 3-8 through 3-11.

The charts in Figures 3-8 through 3-11 are developed from statistical data of past ship construction: Paint losses due to overspray and non-uniform coverage vary from ship area to ship area due to configuration. The quantity of material used in typical ship areas was documented by production on prior ships. From this accumulated data, these charts were developed and

KIND OF PAINT			MARK	NOMINAL FILM THICKNESS (DRY) MICRON/COAT	THEORETICAL PAINT VOLUME GRAM/SQ.M/COAT	REQUIRED PAINT VOLUME GRAM/SQ.M/COAT
SHOP PRIMER	WASH PRIMER		WP	20	135	200
	ZINC EPOXY PRIMER		ZP	18	120	240
	INORGANIC ZINC PRIMER		IZP	15	110	220
SHELL PAINT	BOTTOM ANTI-CORR.	CHLORINATED RUBBER	CRAC	35	115	230
		VINYL	VAC	25	135	270
		TAR EPOXY	TEAC	100	215	450
		EPOXY	EAC	100	200	450
	-	-	-	-	-	-
	-	-	-	-	-	
	-	-	-	-		
	-	-	-			

25 microns = 1 mil paint film thickness

Figure 3-7 : Paint Material Requirements Chart

Values of the required paint volume are based on statistical data of prior ship painting and differ by shipyard.

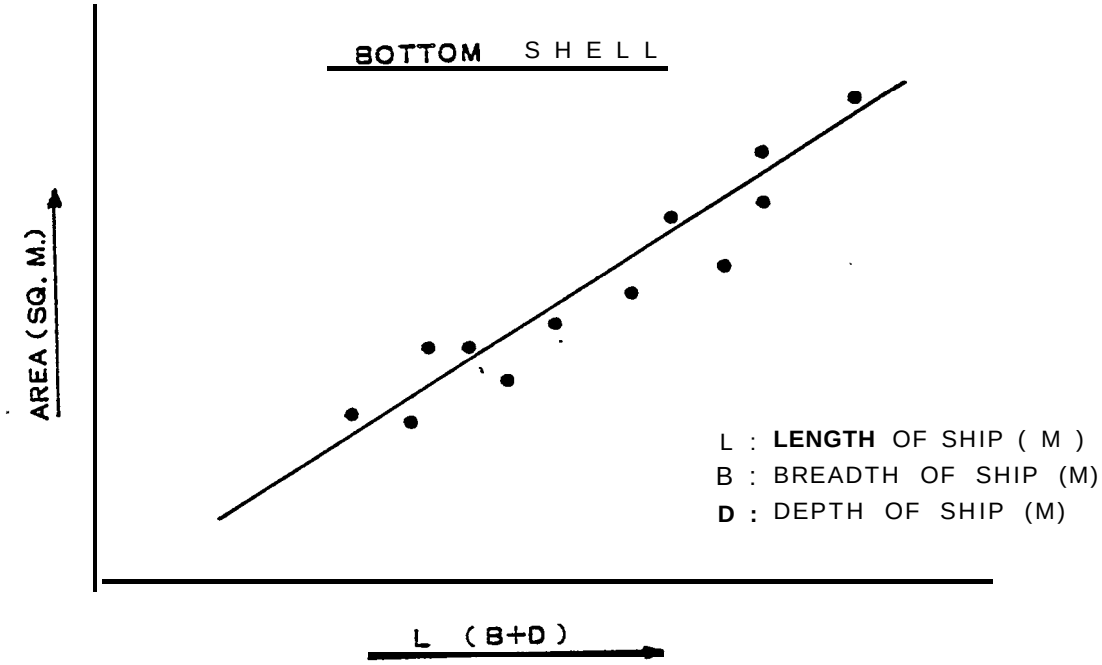


Figure 3-8 : Bottom Shell Area Estimation Chart

The boot top shell and top side shell estimation charts are similar to this .

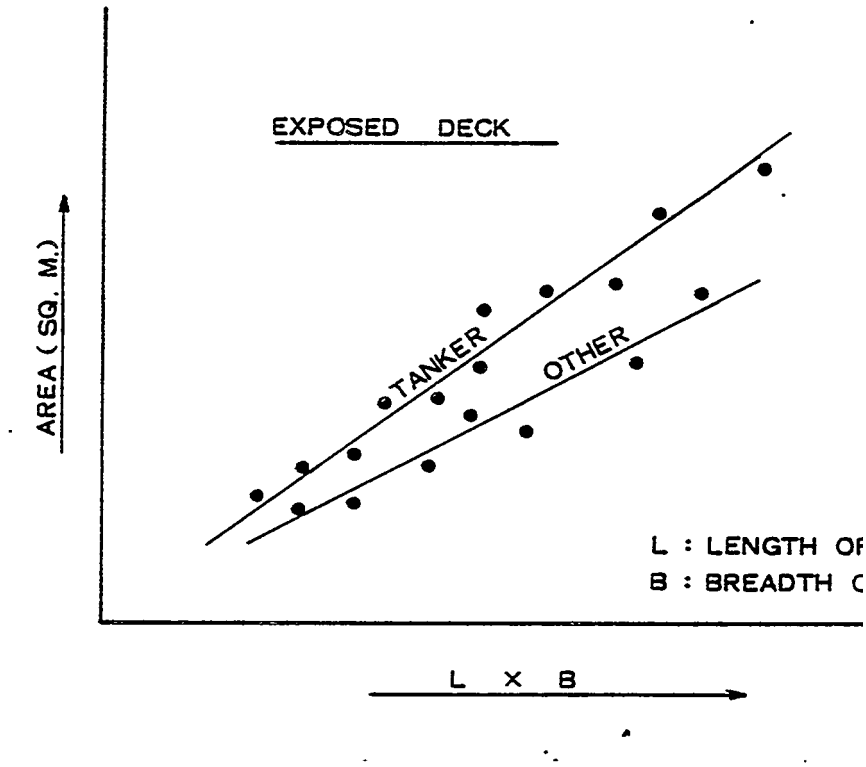


Figure 3-9 : Exposed Deck Area Estimation Chart

The curve for ships other than tankers, and not including the hatch cover areas.

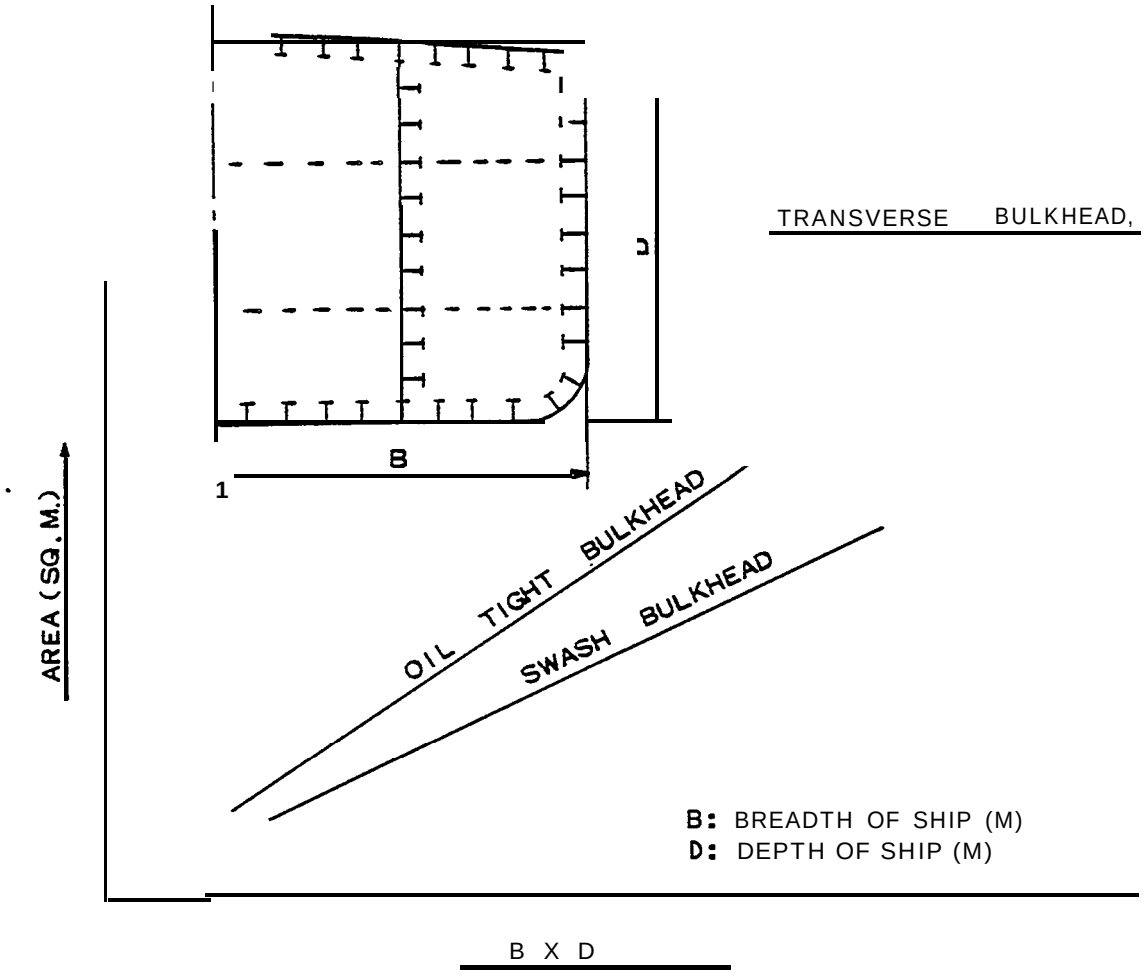


Figure 3-10 Transverse Bulkhead Area Estimation Chart

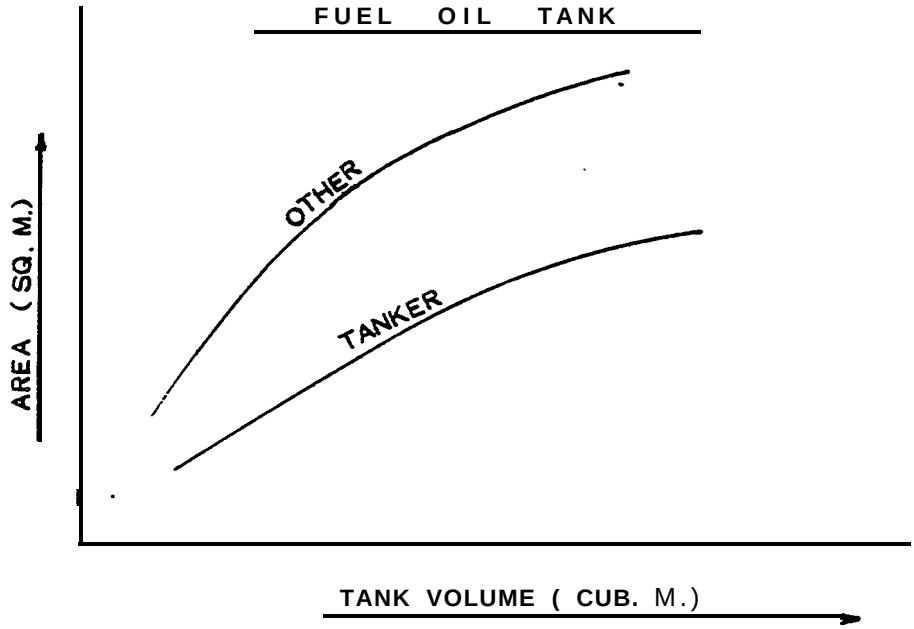


Figure 3-11 : Fuel Oil Tank Area Estimation Chart

Estimation charts for double bottom tanks, fresh water tanks and lub. oil sump tanks are made in the same manner.

refined to provide a sound basis for estimating paint consumption.

At each subsequent planning phase, the paint area is obtained by using:

- the key plans for the midship section, shell expansion, construction profile and so on during the system planning phase, and
- the detailed drawings for hull structure block drawings, fitting arrangement plans, component detail drawings and so on during the zone planning phase.

Once the painting is completed, all paint consumption data is fed back to engineering for updating the estimation charts to improve their accuracy.

The painting area and the paint material requirements are documented for each system on the budget control list, which is revised at each subsequent planning phase. The budget control list is employed as a working budget for material and man-hour requirements' for the entire ship construction. It is an important control for the entire shipbuilding cost. As the budget control list is revised, it helps monitor costs and provide feedback for future projects.

3.2 SYSTEM PLANNING

System planning involves the preparation of the coating specification which is developed from the paint scheme described in contract planning. A second purpose of system planning is *to* check the paint scheme from a technical view point, namely:

- Test the application of new types of paint materials and new painting procedures. For example:
  - the shipyard application of high-build type anti-fouling paint (150 micron) which would not have been previously applied at the shipyard;

the adhesion of the material with the tar epoxy paint on the bottom, the epoxy paint on the boot top and the chlorinated rubber paint on the freeboard would be determined;

technical support is supplied by the coating manufacturer for these demonstrations.

- Optimization of orifice size, pressure and other application requirements must be verified using shipyard equipment.
- Reference past production painting experience *to* determine if any special application requirements are necessary or if problems were experienced on the selected coating systems.
- Resolve any pending items from contract planning, which are left over due to lack of time in the technical negotiations for ship specifications.

A third purpose in system planning is *to* develop the material list (MLS) for painting to provide the Purchasing Department with preliminary ordering requirements. The paint material requirements are estimated in this planning phase by calculating the paint area from hull structure key plans such as for the midship section, shell expansion and construction profile rather than the estimation charts which were used during the contract planning phase. The area table which is developed is also used as a basis for estimating the required man-hours for the Painting Department.

The material requirements must be indicated for areas within each system on the MLS such as the bottom, boot top, free board, upper deck, etc. After completion of the MLS, the budget control list is updated.

As the primary technical painting requirements are specified in the paint scheme during contract planning, the paint

specifications should be developed in accordance with the scheme using the following procedure:

(1) The paint material manufacturer is selected His product color and number is defined.

(2) Identifying and listing areas and compartments, outfit components (including auxiliary machinery) and equipment *to* be painted at the unit stage.

(3) Specifying the grade of surface preparation, number of coats, and paint film thickness.

(4) Specifying and adding general requirements and quality control information for surface preparation, inspection and painting methods. For example:

a. General requirements:
   - Paint work to be accomplished according to shipyard practices and recommendations of the paint manufacturer.
   - Non-ferrous material not to be painted.
   - Finishing color for machinery and equipment in accordance with the manufacturer's standards.

b. Surface preparation:
   - Surface preparation by abrasive blasting, power tool or pickling.
   - Grade of surface preparation to be shown in table.

co Inspection:
   - Dry film thickness measurement instrument.
   - Method of inspection.
   - Inspection schedule.

d. Painting methods:
   - Paint method to be carried out by airless spray, roller, brush or other.
   - When and if thinner is to be used.
   - Method of touch-up.

e. Miscellaneous:

- Edges formed by gas cutting or welding need not be chipped or ground.
- Welding bead need not be ground.

Sample coating specifications are shown in Figures 3-12 and 3-13. The coating specification is submitted to the owner for approval together with the color scheme (color sample book), paint boundary line for the shell, etc.

The other engineering design groups as well as the Paint Design Group take the following items into consideration in their design in order to enhance painting productivity.

- The location, number and size of man holes and access holes should be examined and indicated on drawings for worker's access and for ventilation.
- The hull structure and outfitting components in confined spaces should be designed so as to make painting easier.
- Paint work should be shifted from the on-board stage to on-block and on-unit stages.
- Welding work for fitting of components to the hull structure and cutting holes should be completed before painting the hull structure.
- The superstructure (accommodation quarter) should be assembled on the ground and painted prior to its erection on the ship.
- The final paint coat should be applied to the hull structure and outfitting components at the on-block and on-unit stages before erection, as much as possible, and particularly in those areas which must be scaffolded after erection.

While the design engineering groups are responsible for the above activities, the Painting Department is involved as well during the system planning phase. Their responsibilities are to develop:

PAINTING AREA				GRADE OF SURFACE PREPARATION		SHOP PRIMER	PAINT & NUMBER OF COATS 3					COLOUR MUNSELLS NOTATION	REMARKS
				BEFORE SHOP PRIMER	BEFORE FIRST COATING		1	2	3	4	5		
OUT SIDE SHELL	BOTTOM	KEEL	BEFORE LAUNCHING	SP-10	SP-3	IZP	CRAC	CRAC	CRAF	CRAF		RED	CRAC : MIN 160 MIC. IN TOTAL
			AT DOCKING										
		EXCEPT ABOVE	BEFORE LAUNCHING	SP-10	SP-3	12P	CRAC	Cfuc	CRAF				INCLUDING SEA CHEST
			AT DOCKING							CRAF			
	BOOT TOP		BEFORE LAUNCHING	SP-10	SP-3	12P	CRAC	CRAC	CRBT			RED	CRAC : MIN. 150 MIC.
			AT DOCKING							CRBT			
	TOP SIDE		BEFORE LAUNCHING	SP-10	SP-3	IZP	CRAC	CRAC	CRTS			BLACK (N-1.O)	CRAC : MIN. 75 MIC.
			AT DOCKING							CRTS			
	BOW CHOCK AND TOP		OUT SIDE	SP-10	SP-3	IZP	CRAC	CRAC	CRTS	CRTS		BLACK (N- 1.0)	
			IN SIDE	SP-10	SP-3	IZP	CRRP	CRRP	CRFC	CRFC		LIGHT GREEN (2.5Y 9/5)	
	RUDDER AND BILGE KEEL		OUT SIDE	SP-10	SP-3	1ZP	CRAC	CRAC	CRAF	CRAF			
			IN SIDE	SP-10	SP-3	IZP	BS						

1 SP10 "Near White Blast Cleaning"
SP-3 "Power Tool Cleaning"

2 1ZP = Inorganic Zinc Primer

3 CRAC = Chlorinated Rubber Anti-Corrosive
CRAF Chlorinated Rubber Anti-Fouling
CRBT = Chlorinated Rubber Boot Top Paint
CRRP = Chlorinated Rubber Primer Paint
CRTS = Chlorinated Rubber Top Side Paint

Figure 3-12: Hull Structure Paint Specification

PAINTING AREA				GRADE OF SURFACE PREPARATION		SHOP PRIMER	PAINT & NUMBER OF COATS 3					COLOUR MUNSELLS NOTATION	REMARKS
				BEFORE SHOP PRIMER	BEFORE FIRST COATING		1	2	3	4	5		
OUT SIDE SHELL	BOTTOM	KEEL	BEFORE LAUNCHING	SP-10	SP-3	IZP	CRAC	CRAC	CRAF	CRAF		RED	CRAC : MIN 160 MIC. IN TOTAL
			AT DOCKING										
		EXCEPT ABOVE	BEFORE LAUNCHING	SP-10	SP-3	12P	CRAC	Cfuc	CRAF				INCLUDING SEA CHEST
			AT DOCKING							CRAF			
	BOOT TOP		BEFORE LAUNCHING	SP-10	SP-3	12P	CRAC	CRAC	CRBT			RED	CRAC : MIN. 150 MIC.
			AT DOCKING							CRBT			
	TOP SIDE		BEFORE LAUNCHING	SP-10	SP-3	IZP	CRAC	CRAC	CRTS			BLACK (N-1.O)	CRAC : MIN. 75 MIC.
			AT DOCKING							CRTS			
	BOW CHOCK AND TOP		OUT SIDE	SP-10	SP-3	IZP	CRAC	CRAC	CRTS	CRTS		BLACK (N- 1.0)	
			IN SIDE	SP-10	SP-3	IZP	CRRP	CRRP	CRFC	CRFC		LIGHT GREEN (2.5Y 9/5)	
	RUDDER AND BILGE KEEL		OUT SIDE	SP-10	SP-3	1ZP	CRAC	CRAC	CRAF	CRAF			
			IN SIDE	SP-10	SP-3	IZP	BS						

1 SP10 "Near White Blast Cleaning"
SP-3 "Power Tool Cleaning"

2 1ZP = Inorganic Zinc Primer

3 CRAC = Chlorinated Rubber Anti-Corrosive
CRAF Chlorinated Rubber Anti-Fouling
CRBT = Chlorinated Rubber Boot Top Paint
CRRP = Chlorinated Rubber Primer Paint
CRTS = Chlorinated Rubber Top Side Paint

Figure 3-12: Hull Structure Paint Specification

- Paint master plan,
- Paint master schedule,
- Pallet lists,
- Detailed schedules such as on-block and on-board schedules, and monthly, weekly and daily schedules,
- Determination of manpower requirements,
- Control plans for paint materials, coating quality, safety, sub-contractors, etc., and
- Technical study plans .

The paint master plan describes how to paint each ship effectively. Decisions must be made on what should be accomplished prior to erection at what location. Items to be considered are:

- reduce painting positions by shifting blocks so that down hand or vertical painting may be maximized and reducing the necessity of painting in high places that require the use of scaffolding to readily accessible places.
- facilitate the use of temperature and humidity controlled buildings, especially for sophisticated and less forgiving coatings,
- provide safer environments without implementing devices that would encumber workers,
- prevent in-process rust and associated re-work,
- minimize the use of scaffolds needed only for surface preparation and painting, and
- maintain an even work load throughout the entire shipbuilding process in order to avoid large work volumes in the final stages that could jeopardize scheduled delivery.

Additionally, the paint master plan includes items such as:

- Assemble accommodation blocks on the ground and final coat before erection.
- Final coat the boot top and the free board at the on-block stage rather than the on-board stage (before launching) as shown in Figure 3-14.

CRAC = Chlorinated Rubber Anti-corrosive
CRAF = Chlorinated Rubber Anti-Fouling
CRBT = Chlorinated Rubber Boot Top Paint
CRTS = Chlorinated Rubber Top Side Paint

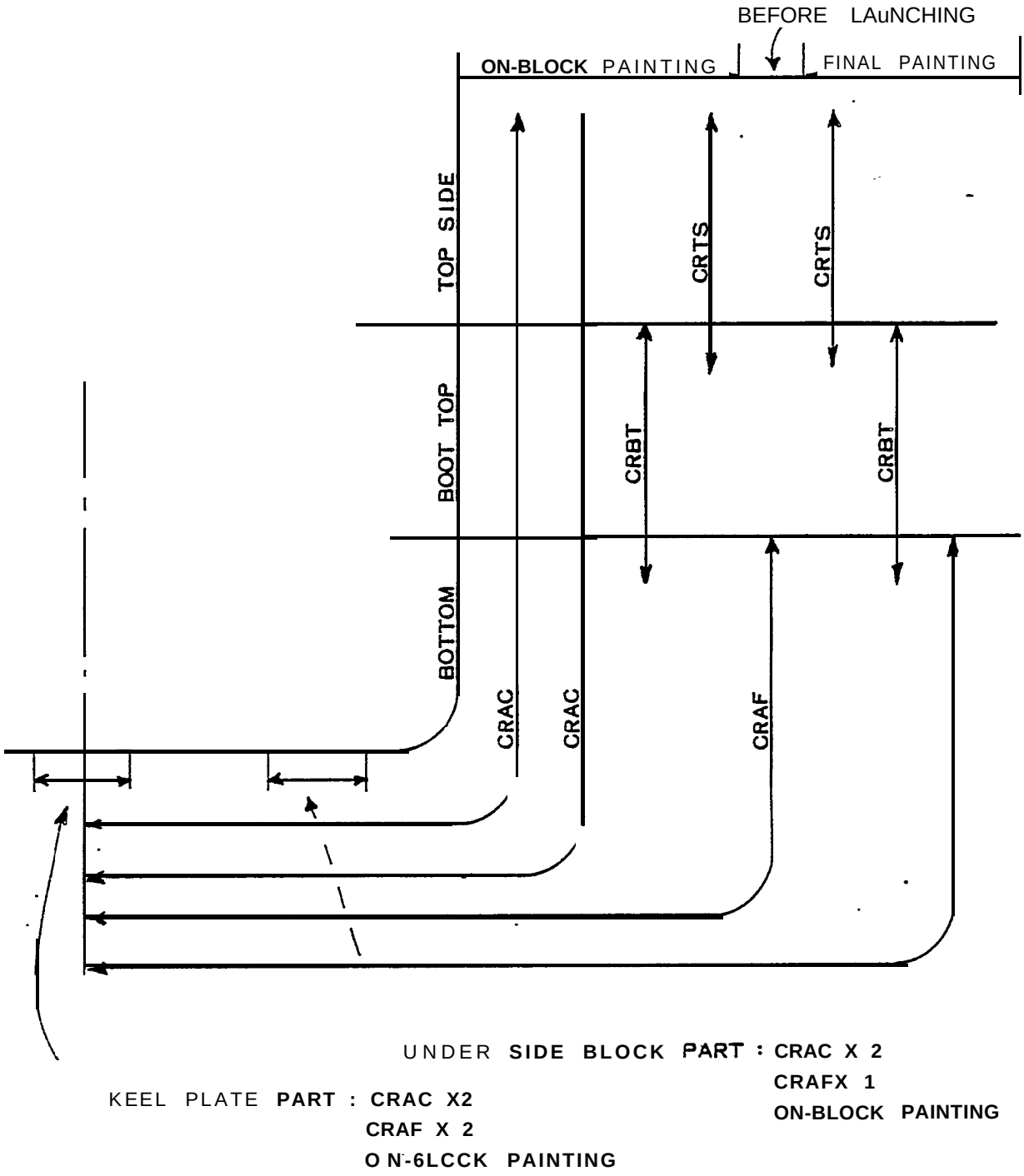


Figure 3-14 : Hull Structure Paint Master Plan.

- Exterior auxiliary machinery and equipment is coated by the manufacturer except for the final coat, which iS applied before delivery for cosmetic reasons, as shown in Figure 3-15.

The paint master schedule is prepared in accordance with the above paint master plan *to* increase paint work efficiency. This paint master schedule is coordinated with the hull construction master schedule and outfitting master schedule; and when integrated, become the IHOP schedule (discussed in Section 2).

In order to successfully implement ZPTM, the following items should be indicated on the paint master schedule, and integrated into the IHOP schedule.

- Painting intervals between coats: for instance, the overcoating time from shop priming of plate and shapes to the application of the next coat on-block should be sufficiently short so as to avoid rusting. Exposure. time of the shop primer should be minimized because steel must be cut, fabricated and assembled before the next anti-corrosive coat is applied. This exposure time may approach the maximum allowable time before rusting occurs. It is generally accepted that the allowable exposure. period for Zinc Epoxy Primer (ZP) is 6 months, and that Inorganic Zinc Primer (IZP) is in excess of 6 months. Therefore, the type of shop primer should be selected that would ensure that the production interval is within its allowable exposure period. The hull coristruction planning and engineering group should endeavor to reduce the intervals between production processes; that is shot-blasting, shop primer coating, part fabrication, block assembly, on-block outfitting and erection.
- Hull blocks should be completed prior to painting to minimize surface preparation and painting re-work caused by cutting, fitting and welding. For instance,

SECTION		STAGE		
		AT FABRICATION STAGE OR MANUFACTURER	ON-BLOCK	ON-BOARD
AUX. NACHINERY AND EQUIPMENT	EXTERIOR PART	TO BE COATED EXCEPT FINAL COAT		FINAL COAT
	INTERIOR PART	TO BE COATED INCLUDING FINAL COAT (COVERED WITH VINYL)		
OTHER COMPONENTS		TO BE COATED ONLY WITH ANTI-CORROSIVE PAINT		UNDER COAT AND FINAL COAT

NOTES: 1. "OTHER COMPONENTS" ARE LADDERS, VENTILATION TRUNKS, PIPES, PIPE SUPPORTS, ETC.

2. THE MAST, POST, CRANE, FUNNEL, ETC. ARE PAINTED THROUGH THE FINAL COAT AT THE FABRICATION STAGE (BEFORE ERECTION) For SAFETY PURPOSES.

3. THE HATCH COVER IS PAINTED EXCEPT THE FINAL COAT, WHICH IS APPLIED BEFORE DELIVERY IN ORDER TO COVER THE AREA DIRTIED BY WORK-

4. EXTERIOR AUXILIARY MACHINERY AND EQUIPMENT IS THE SAME AS (3).

5. ON-BLOCK PAINTING FOR OUTFIT COMPONENTS IS SELDOM DONE.

Figure 3-15 : Outfitting Components Paint Master Plan.

holes reinforcements and machinery foundations for outfitting should be completed, and the hull blocks finish trimmed to size.

- On-board outfitting of components should be minimized to reduce on-board burning. Cutting and welding on the walls and overheads should be finished during on-block outfitting as much as possible.
- The shop primer applied to plates and shapes should not disturb the efficiency of marking, cutting and welding operations. Otherwise, hull block dimension accuracy will be hard to maintain and may require trimming for correction.
- The paint should not generate high levels of fumes during burning, cutting and welding operations, so as to reduce worker exposure.

In U.S. shipyards, shop primers are totally removed by abrasive blasting at the block stage and the surface is either re-primed or a complete paint system is applied. Contrary to the U.S. practice, all large Japanese shipyards shot-blast and shop-prime all structure plates and shapes. The primed structural steel is cut, welded, fabricated and assembled into large blocks or modules. Following the on-block outfitting of these modules, the primer is overcoated with subsequent coats of paint. Abrasive blasting is not used, but rather damaged or deteriorated primer is power tool cleaned and touched-up prior to overcoating.

The application of. new or unfamiliar paint material or the institution of new painting practices are initiated on a trial basis. The paint material manufacturer is requested to have a paint engineer available at these tests to advise the shipyard personnel on correct procedures.

A pallet list for painting should be prepared in accordance with the paint master plan and paint master schedule. This list should indicate what areas to be painted, and at what stage.

In the next topic, zone planning, we will discuss the transition from a system orientation to a zone orientation and the attendant requirements.

3.3 ZONE PLANNING

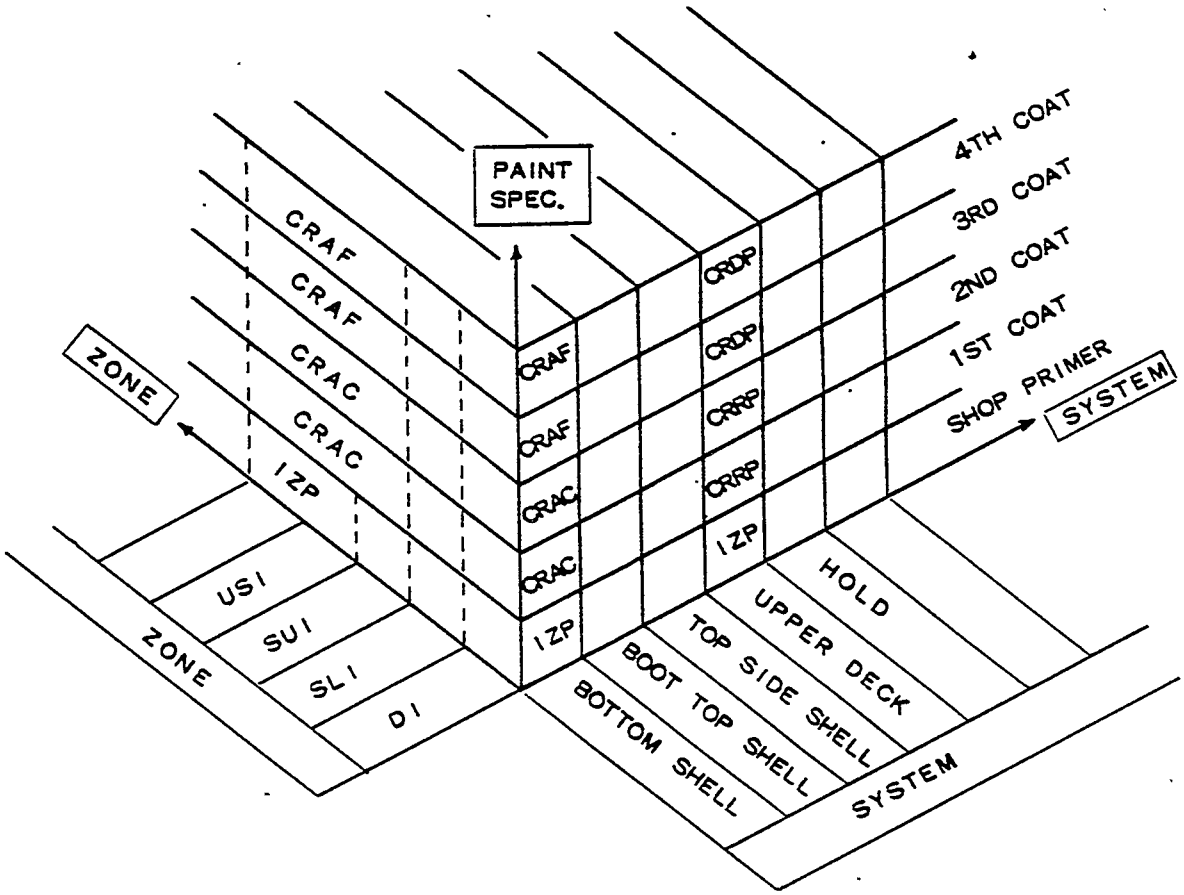
Paint specifications are defined system by system, but the actual paint work is carried out by zones utilizing the zone painting method. Thus, a transition design from a system-orientation to a zone-orientation is necessary. In this design phase, three aspects are required; system, zone and paint specifications instead of just the two aspects, system and paint specifications. The output of the preceding planning phase (as shown in Figure 3-16) becomes a guideline for the zone planning phase. In the work instruction - design phase during zone planning, work instruction drawings are prepared for each pallet.

3.3.1. Transition Design

In the transition phase, a paint transition drawing by zone is prepared as a guide plan for the next planning phase, as illustrated in Figures 3-17 and 3-18.

Figure 3-17 is a typical transition drawing for a hull structural block. It identifies the block, surface preparation requirements, paint material, what areas to be painted, and at what stage the paint is to be applied; on-block, before launching, and on-board (before the delivery). The painting sequence is defined by the Painting Department and is provide to the Paint Design Group. The block size in Figure 3-17 is an average block size. When using smaller blocks (or sub-blocks), the number of blocks increase, and the number of tables becomes voluminous.

The transition drawing for outfitting components (Figure 3-18) indicates the type of paint by compartments, the stage when paint

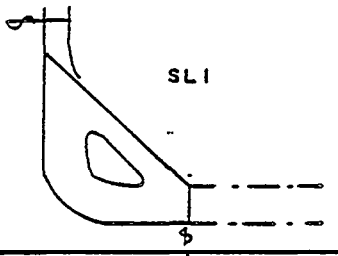


CRAC = Chlorinated Rubber Anticorrosive
CRAF = Chlorinated Rubber Anti-Fouling
CRDP = Chlorinated Rubber Deck Paint
CRRP = Chlorinated Rubber Primer Paint
IZP = Inorganic Zinc Primer

Figure 3-16 : Paint Transition Design.

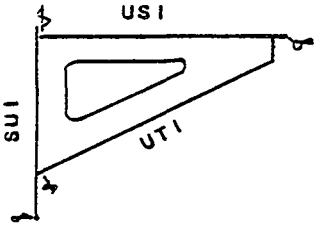
PAINT TRANSITION TABLE

HULL №	× × × ×	BLOCK NAME	SLI, SUI, USI, UTI



SLI = Boot Top Shell

PAINTING AREA	GRADE OF SURFACE PREPARATION		SHOP PRIMER	ON-BLOCK COATING			BEFORE LAUNCHING		FINAL COATING	
	BEFORE SHOP PRIMER	BEFORE FIRST COATING		1	2	3	1	2	1	2
BOTTOM SHELL	SP-10	SP-3	IZP	CRAC	CRAC		CRAF		CRAF	
HOLD	SP-10	SP-3	IZP	CRRP	CRRP				CRHP	
BALLAST TANK	SP-10	SP-3	IZP	TE						



SUI = Top Side Shell
USI = Upper Deck
UTI = Hold

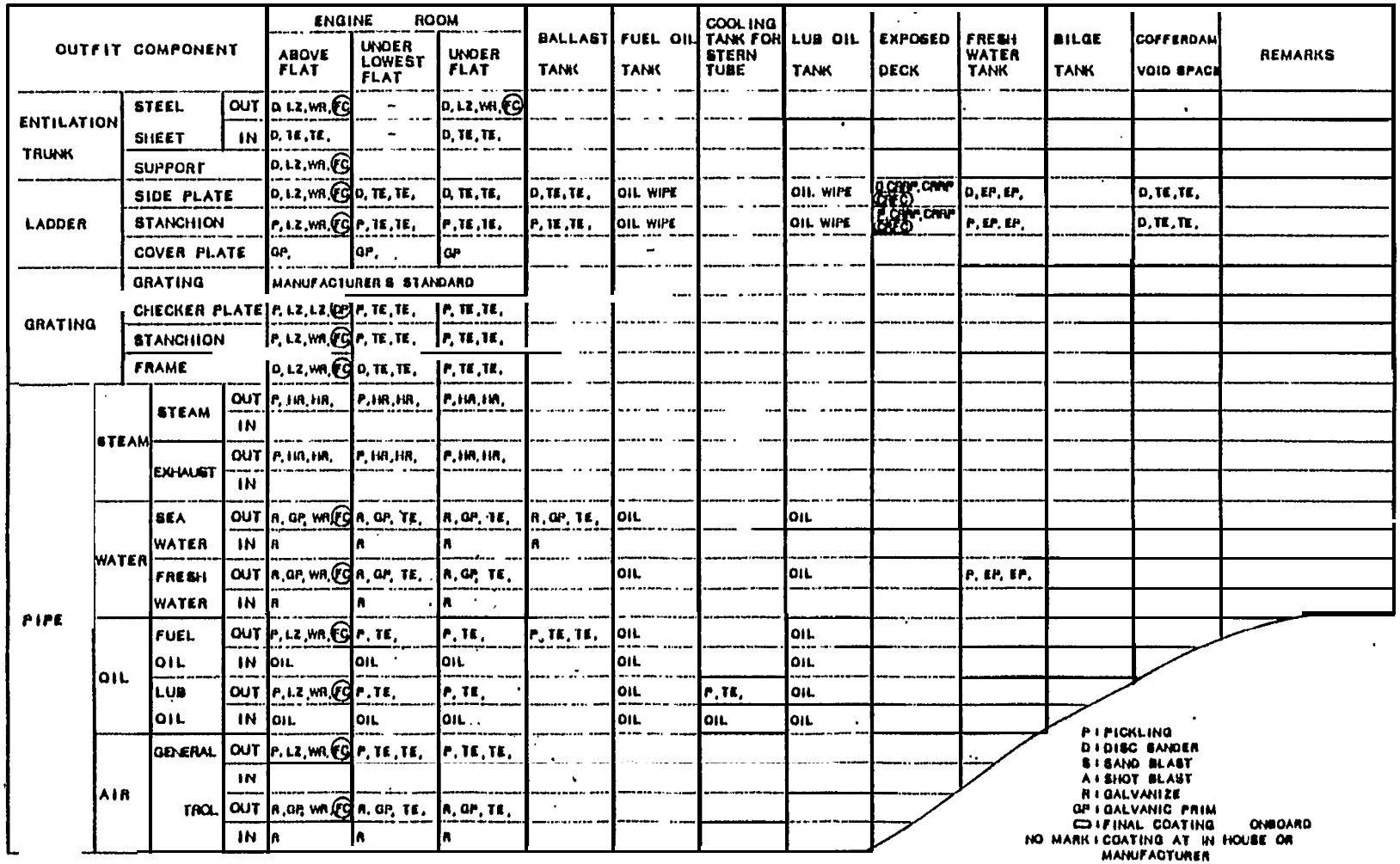
PAINTING AREA	GRADE OF SURFACE PREPARATION		SHOP PRIMER	ON-BLOCK COATING			BEFORE LAUNCHING		FINAL COATING	
	BEFORE SHOP PRIMER	BEFORE FIRST COATING		1	2	3	1	2	1	2
TOP SIDE SHELL	SP-10	SP-3	IZP	CRAC	CRAC	CRTS			CRTS	
UPPER DECK	SP-10	SP-3	IZP	CRRP	CRRP	CRDP			CRDP	
HOLD CEILING	SP-10	SP-3	IZP	CRRP	CRRP					
BALLAST TANK	SP-10	SP-3	IZP							

Figure 3-17 : Hull Structure Paint Transition Table.

1 Steel Structures Painting Council (SSPC)
Surface Preparation Specifications
SP-10 = "Near White Blast Cleaning"
SP-3 = "Power Tool Cleaning"

2 IZP = Inorganic Zinc Primer

3 CRAC = Chlorinated Rubber Anti-Corrosive
CRAF = Chlorinated Rubber Anti-Fouling
CRDP = Chlorinated Rubber Deck Paint
CRHP = Chlorinated Rubber Hold Paint
CRRP = Chlorinated Rubber Primer Paint
CRTS = Chlorinated Rubber Top Side Paint
TE = Tar Epoxy Paint



OUTFIT COMPONENT				ENGINE ROOM: ABOVE LOWEST FLAT	ENGINE ROOM: UNDER LOWEST FLAT	ENGINE ROOM: UNDER FLAT	BALLAST TANK	FUEL OIL TANK	COOLING TANK FOR STERN TUBE	LUB OIL TANK	EXPOSED DECK	FRESH WATER TANK	BILGE TANK	COFFERDAM VOID SPACE	REMARKS
VENTILATION TRUNK	STEEL SHEET		OUT	D, LZ, WR, FC	–	D, LZ, WR, FC									
			IN	D, TE, TE,	–	D, TE, TE,									
	SUPPORT			D, LZ, WR, FC											
LADDER	SIDE PLATE			D, LZ, WR, FC	D, TE, TE,	D, TE, TE,	D, TE, TE,	OIL WIPE		OIL WIPE	D, CRRP, CRRP (CRFC)	D, EP, EP,		D, TE, TE,	
	STANCHION			P, LZ, WR, FC	P, TE, TE,	P, TE, TE,	P, TE, TE,	OIL WIPE		OIL WIPE	P, CRRP, CRRP (CRFC)	P, EP, EP,		D, TE, TE,	
	COVER PLATE			GP,	GP,	GP		–							
GRATING	GRATING			MANUFACTURER'S STANDARD											
	CHECKER PLATE			P, LZ, LZ, DP	P, TE, TE,	P, TE, TE,									
	STANCHION			P, LZ, WR, FC	P, TE, TE,	P, TE, TE,									
	FRAME			D, LZ, WR, FC	D, TE, TE,	P, TE, TE,									
PIPE	STEAM	STEAM	OUT	P, HR, HR,	P, HR, HR,	P, HR, HR,									
			IN												
		EXHAUST	OUT	P, HR, HR,	P, HR, HR,	P, HR, HR,									
			IN												
	WATER	SEA WATER	OUT	R, GP, WR, FC	R, GP, TE,	R, GP, TE,	R, GP, TE,	OIL		OIL					
			IN	R	R	R	R								
		FRESH WATER	OUT	R, GP, WR, FC	R, GP, TE,	R, GP, TE,		OIL		OIL		P, EP, EP,			
			IN	R	R	R									
	OIL	FUEL OIL	OUT	P, LZ, WR, FC	P, TE,	P, TE,	P, TE, TE,	OIL		OIL					
			IN	OIL	OIL	OIL		OIL		OIL					
		LUB OIL	OUT	P, LZ, WR, FC	P, TE,	P, TE,		OIL	P, TE,	OIL					
			IN	OIL	OIL	OIL		OIL	OIL	OIL					
	AIR	GENERAL	OUT	P, LZ, WR, FC	P, TE, TE,	P, TE, TE,									
			IN												
		TROL	OUT	R, GP, WR, FC	R, GP, TE,	R, GP, TE,									
			IN	R	R	R									

P : PICKLING
D : DISC SANDER
S : SAND BLAST
A : SHOT BLAST
R : GALVANIZE
GP : GALVANIC PRIM
▭ : FINAL COATING ONBOARD
NO MARK : COATING AT IN HOUSE OR MANUFACTURER

CRFC = Chlorinated Rubber Finish Paint
CRRP = Chlorinated Rubber Primer Paint
DP = Deck Paint
EP = Epoxy Paint
FC = Finish Paint
HR = Heat Resisting Paint
LZ = Lead Zinc Chromate Primer
TE = Tar Epoxy Paint
WR = White Rust Resisting Paint

Figure 3-18: Outfitting Components Paint Table

is applied, and the manufacturing area, when applicable. All compartments and all components must be listed in the transition table.

3.3.2. Work Instruction Design

In the preceding phase, transition design, the paint transition drawings indicate each block or compartment and roughly define the area to be painted. Thus, work instruction drawings can be prepared by pallet utilizing these transition drawings. Figures 3-19, 3-20, and 3-21 are derived from Figures 3-17 and 3-18.

In order to plan the painting of the hull structure,. it is necessary to know assembly sequence of the hull block as the painting depends on this stage, as shown in Figure 3-22. The figure depicts the upper freeboard-block of a bulk carrier divided into "A", "B", and "C", stages of assembly. It *also* demonstrates the areas to be painted at these stages. Areas to be painted on each pallet must be indicated on the work instruction drawings. The following must be taken into consideration in determining the stage at which the painting should be performed.

- Normally, it is done in accordance with the hull block construction process, but if necessary, the painting department may ask to alter the schedule of the block assembly in order to enhance paint work efficiency.
- Reduce the necessity of scaffolding (if possible) or unnecessary steps.
- Maximize painting on-block and minimize painting on-board.

On-block paint work for the hull structure is indicated block by block as shown in Figure 3-19, and the outfit component paint specification (which corresponds to the on-block paint work for hull structure) is done component by component as shown in Figure. 3-13.

The next stage, on-board painting work is performed on a large zone similar to a system such as the bottom shell, boot top shell, free board shell and upper deck for the hull structure, and outfitting components. Work instruction drawings are prepared by zones, as shown in Figures 3-20 and 3-21.

In order to develop the material list for painting, it is first necessary to determine the square meters of the area to be painted. In this design phase, the paint area must be re-calculated by using detailed drawings such as the hull block structure drawings, fitting arrangements, and detailed component drawings. Some areas can be obtained from the data prepared by other design groups for other purposes. For instance, the steel surface area is shown in the calculation sheets of hull block weight and pipe lengths (from which the pipe area is calculated) and are shown in the summary table of pipe piece drawings per pallet.

The determined paint area must be indicated in the work instruction drawings as shown in Figures 3-19, 3-20 and 3-21. These tables provide the data for the material lists. The material lists per pallet (MLF) are prepared and issued to the Purchasing Department and Painting Department for material requisitioning, as shown in Figure 3-23. The Painting Department then informs the Purchasing Department of the quantity of material and delivery time required.

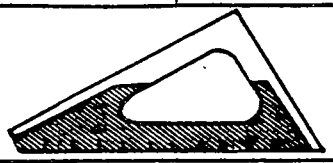
After completion of the MLF, the budget control list (previously based on the MLS) must be updated using the new data.

In order to prepare the paint schedule, a design engineer should know the production procedure and the schedule for painting, hull construction, and outfitting because the painting is integrated into the hull construction and outfitting schedules, as shown in Figures 3-24 and 3-25.

CRAC = Chlorinated Rubber Anti-Corrosive
CRRP = Chlorinated Rubber Primer Paint
TE = Tar Epoxy Paint

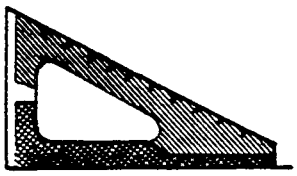
ON-BLOCK PAINT WORK TABLE

HULL NO	X X X X	BLOCK NAME	UT1, US1, SU1



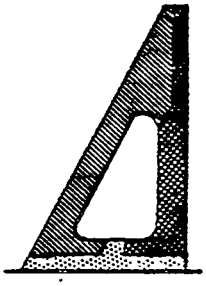
UT1 = Hold

	SURFACE AREA	PAINT AREA	COATING 1	2	3	4	TOTAL AREA
	SQ.M	SQ.M					SQ.M
NO. 5. TOP SIDE TANK	784	706	TE				706
NO. 5. HOLD	300	270	CRRP	CRRP			540
TOTAL		976					1,246



US1 = Upper Deck

	SURFACE AREA	PAINT AREA	1	2	3	4	TOTAL AREA
UPPER DECK	259	233	CRRP	CRRP			466
NO. 5. TOP SIDE TANK	584	526	TE				526
NO. 5. HOLD	31	28	CRRP	CRRP			56
TOTAL		787					1.048



SU1 = Top Side Shell

	SURFACE AREA	PAINT AREA	1	2	3
SIDE SHELL	189	170	CRAC	CRAC	
UPPER DECK	6	5	CRRP	CRRP	

Figure 3-19 : Hull Structure On-Block Paint Work Table

ONBOARD PAINT WORK TABLE

	PAINTING AREA		AREA (SQ. M)	ONBOARD WORK: SURFACE PREP	1	2	3	4	5	6	TOTAL ARER (INCL. S.P)	REMARKS
SHELL	BOTTOM	KEEL	380	SP-3 38	CRAC 38	CRAC 38	CRAF 38	CRAF 38			190	
		FLAT PART	3,460	SP-3 346	CRAC 346	CRAC 346	CRAF 3,460	CRAF 3,460			7,958	
		VERTICAL PART	2,210	SP-3 221	CRAC 221	CRAC 221	CRAF 2,210	CRAF 2,210			5,083	
		SEA CHEST	69	SP-3 7	CRAC 7	CRAC 7	CRAF 69	CRAF 69			159	
		INSIDE OF BILGE KEEL	132	SP-3 13	BS 13	BEFORE LAUNCHING		FINAL COAT			26	
		SUB-TOTAL	6,251	ON-BLOCK							13,416	
	BOOT TOP	BOOT TOP	2,215	SP-3 221	CRAC 221	CRAC 221	CRBT 2,215	CRBT 2,215			6,093	
					ON-BLOCK			FINAL COAT				
		SUB-TOTAL	2,215								5,093	
	TOP SIDE	TOP SIDE	2,436	SP-3 243	CRAC 243	CRAC 243	CRTS 2,436	CRTS 2,436			5,599	
		INSIDE OF HAWSE PIPE	18	SP-3 2	TE 2						4	
		SUB-TOTAL	2,463									

SP-3 : "Power Tool Cleaning (SSPC)"
CRAC : Chlorinated Rubber Anti-Corrosive
CRAF : Chlorinated Rubber Anti-Fouling
CRBT : Chlorinated Rubber Boot Top Paint
CRTS : Chlorinated Rubber Top Side Paint
BS : Bitumen Solution
TE : Tar Epoxy Paint

Figure 3-20 : Hull Structure On-Board Paint Work Table

ONBOARD PAINT WORK TABLE

	PAINTING AREA			AREA (SQ.M.)	ONBOARD WORK							TOTAL AREA (INCL.S.P)	REMARKS
					SURFACE PREP.	1	2	3	4	5	6		
	EXTERIOR PART OUTFITTING	EXPOSED DECK	FORE MAST	160	SP-3 16	CRRP 16	CRRP 16	CRFC 16	CRFC 16			76	
			ACCESS HATCH	30	SP-3 3	CRRP 3	CRRP 3	CRFC 30	CRFC 30			69	
			MOORING OUTFITTING	240	SP-3 24	CRRP 24	CRRP 24	CRFC 240	CRFC 240			552	
			DECK MACHINERY	200	SP-3 10	CRRP 20	CRRP 20	CRFC 20	CRFC 200			280	
			FOUNDATION OF DECK MACHINERY	100	SP-3 10	TE 10						20	
			PIPING AND SUPPORT (BARE)	70	SP-3 7	CRRP 7	CRRP 7	CRFC 70	CRFC 70			161	
			PIPING AND SUPPORT (GALV)	160	–	GP 16	CRFC 160	CRFC 160				316	
			LADDER, HANDRAIL, FLAT	436	SP-3 44	CRRP 44	CRRP 44	CRFC 436	CRFC 436			1,002	
			ANCHOR AND CHAIN	765	–	BS –	BS 765					765	
			ACCOMMODATION LADDER	300	–	GP 30	CRFC 30	CRFC 300				360	
			VENTILATOR	75	SP-3 8	CRRP 8	CRRP 8	CRFC 75	CRFC 75				
			MISC. OUTFITTING	260	SP-3 25	CRRP 25	CRRP 25	CRFC 260	CRFC 260				

Figure 3-21 : Outfitting Components On-Board

SP-3 : "Power Tool Cleaning (SSPC)"
CRFC : Chlorinated Rubber Finish Paint
CRRP : Chlorinated Rubber Primer Paint
BS : Bitumen Solution
TE : Tar Epoxy Paint

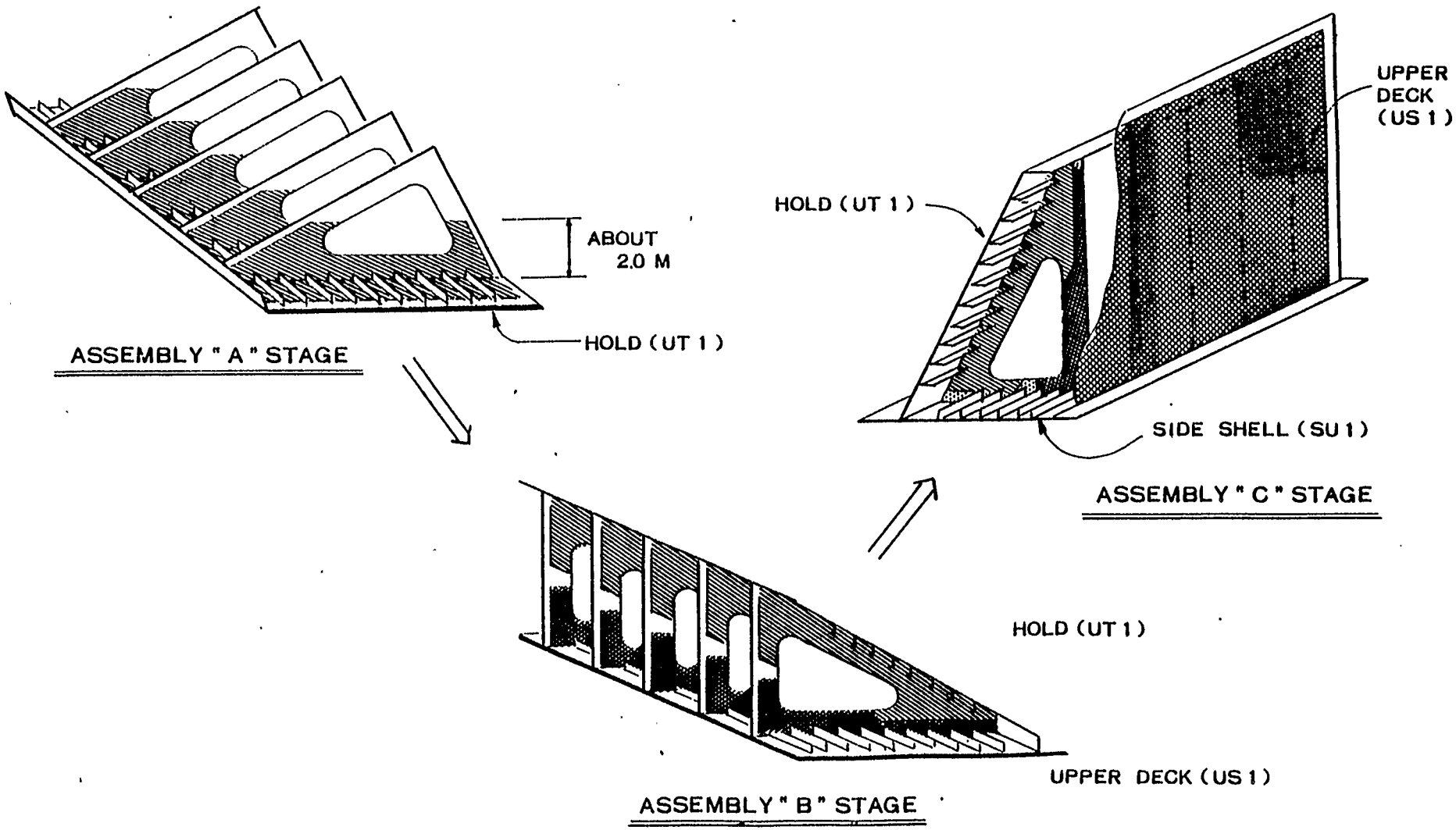


Figure 3-22 : Stages of Assembly.

MATERIAL LIST (MLF)

1	SURFACE AREA (SQ.M.)	PAINT AREA (SO. M.)	PAINT SCHEME	NNORMAL FILM THK (MI CR/ COAT)	REQUIRED VOLUME		PAINT MATERIAL			REQ'D QUANTITY
					GRAM/SOM	KG	SYMBOL	MANUFAC.	BRAND/COLOUR	
	786	708	TEx1	180	810	672	TE	xxx PAINT CO.	BISCON HB BLACK	1,036 KG
	300	270	CRRPX2	30	240	130	CRRP	xxx PAINT CO.	RAVAX A/C HB BROWN	260
U s 1							CRAG	xxx PAINT CO.	RAVAX RED LEAD PRIMER GRAY	163
UPPER DECK	269	2'33	CRRPX2	30	240	112				
NO.6 TOP SIDE TANK	684	626	TEx1	180	810	426				
Ma 6 HOLD	31	20	CRRPX2	30	240	14				
S U 1										
SIDE SHELL	180l	170	CRRPX2	76	480	163				
UPPER DECK	6	6	CRRPX2	30	240	3				
Ha 6 TOP SIDE TANK	62	47	TExt	180	810	38				

HULL No	xxxx	PALLET NO	x x xxx x	BLOCK NAME	UT.1, US1,SU1	

Figure 3-23 : Material List by Pallet (MLF)

CRAC = Chlorinated Rubber Anti-Corrosive
CRRP = Chlorinated Rubber Primer Paint
TE =Tar Epoxy Paint

25 microns = 1 mil paint film thickness

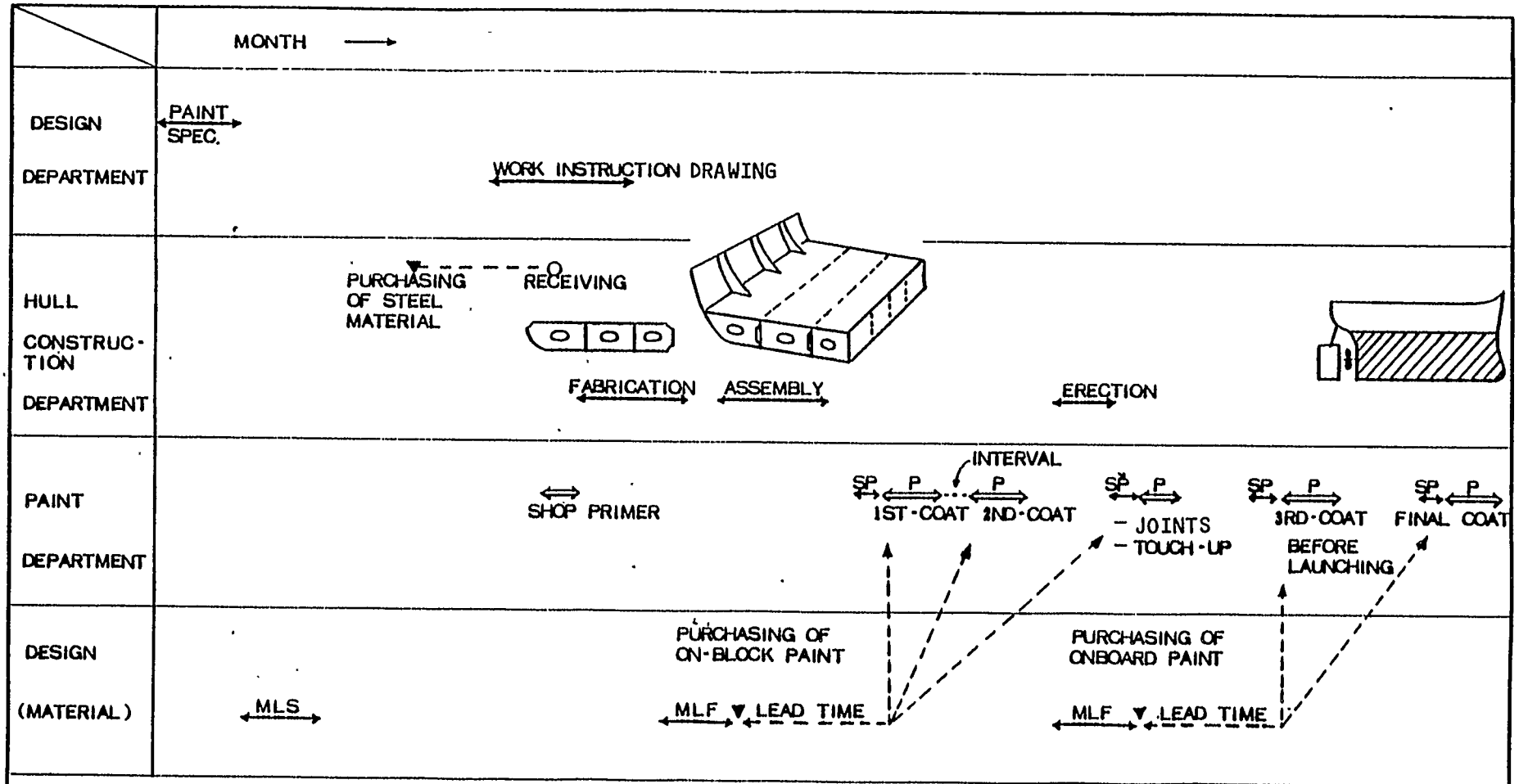


Figure 3-24 : Hull Structure Paint Work Process Chart

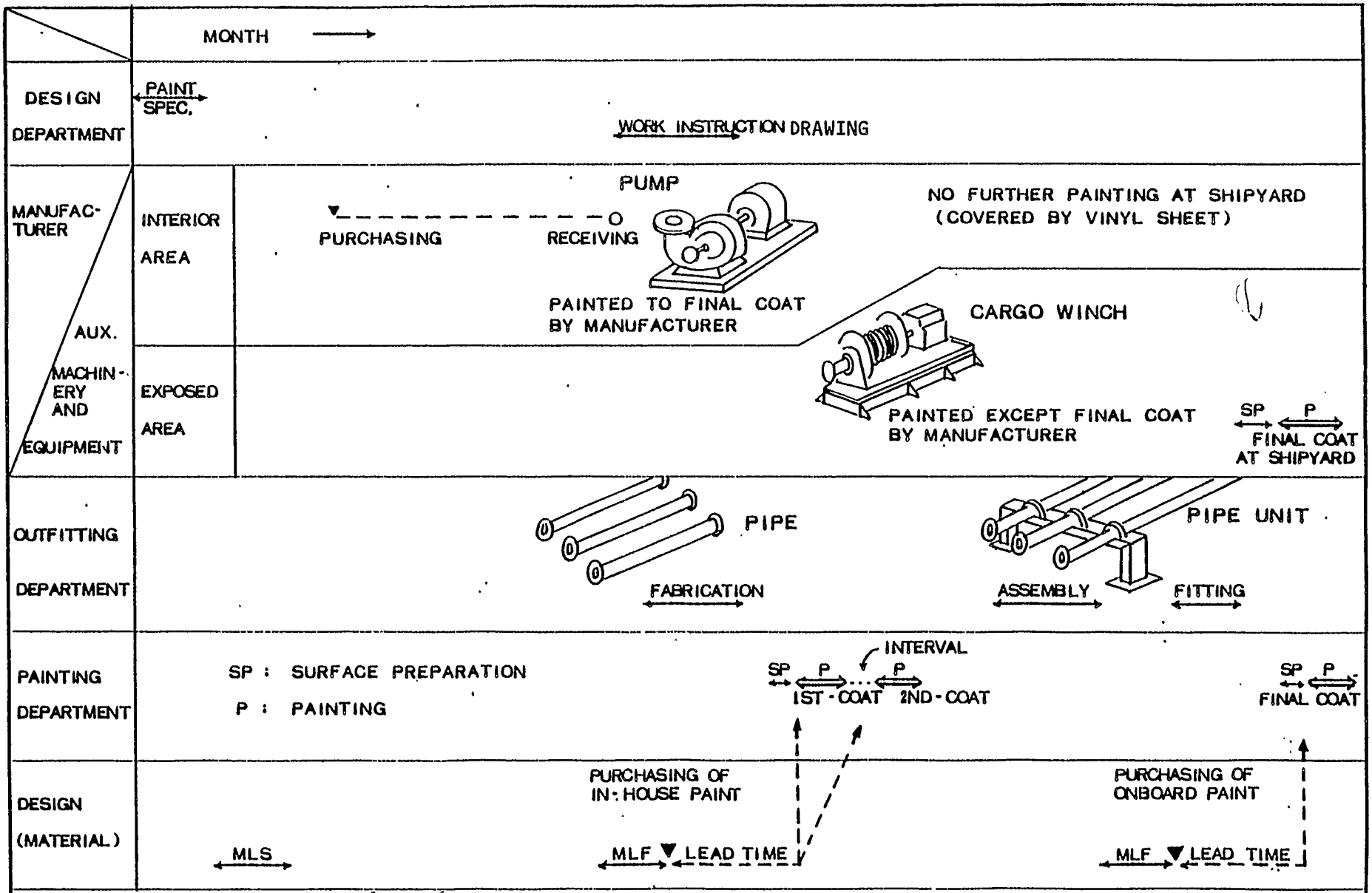


Figure 3-25 : Outfitting Components Paint Work Process Chart

Milestones that must be addressed in the paint schedule are:

- Receipt of steel plate,
- Shop primer application,
- Fabrication (marking and cutting) of steel,
- Hull block assembly,
- On-block outfitting,
- Application of 1st and 2nd coats,
- Hull block erection,
- Master but wells and damaged areas touch-up painting,
- Application of 3rd coat prior to launch,
- Launching,
- On-board outfitting,
- Application of final coat, and
- Delivery of ship

The above must be sequentially carried out in accordance with the IHOP schedule in order to avoid delay and confusion.

The painting schedule should be prepared in time so that all drawings and materials are available at the start of painting. The start and finish dates of each design document must be calculated backwards from the need dates of the drawings and materials as indicated by the IHOP schedule.

The necessary information required for the application of shop primer on steel plates, painting of auxiliary machinery, equipment, and outfitting components must be contained in the purchase order specification. This painting information, however, can be prepared at the work instruction design phase if the purchase order specification is not required until after the work instruction design has been prepared. Paint information must be supplied earlier when the design period is short and the purchase order must be issued prior to the issuance of the work instruction drawing.

The shop primer may be applied either by the steel mill or the shipyard. Therefore, *the* decision whether to buy the steel primed or unprimed must be made before material purchase.

An outline of outfitting components painting requirements is provided in the paint master plan issued by the Painting Department at an early date, namely, at the same time the system planning is done, as shown in Figure 3-15. Painting requirements for outfitting components is developed step by step at each planning phase and is finalized on detailed drawings of components, as shown in Figure 3-26.

Since auxiliary machinery and equipment purchase orders are issued at an early phase in the system planning, the outfitting component paint specification must be prepared and issued before the requisitioning of the material. In some cases, these specifications must be prepared without a transition design drawing. In order to do so, it is essential to make sure that coating requirements are standardized.

Other outfitting components are painted in-house. In either case, final painting is accomplished on-board. The paint work must be indicated on the assembly or piece drawings made by each design group such as the deck outfit design, machinery outfit design and so on, in accordance with the outfitting component paint specifications which are prepared by the paint design group during the work instruction design phase.

There are many components requiring paint. The numerous drawings involved make descriptions of paint requirements confusing. A symbolic paint code system is developed in order *to* easily indicate the paint work for outfit components as in Figure 3-26. This code system is very useful as it facilitates the interpretation of drawings. The code system enables designers

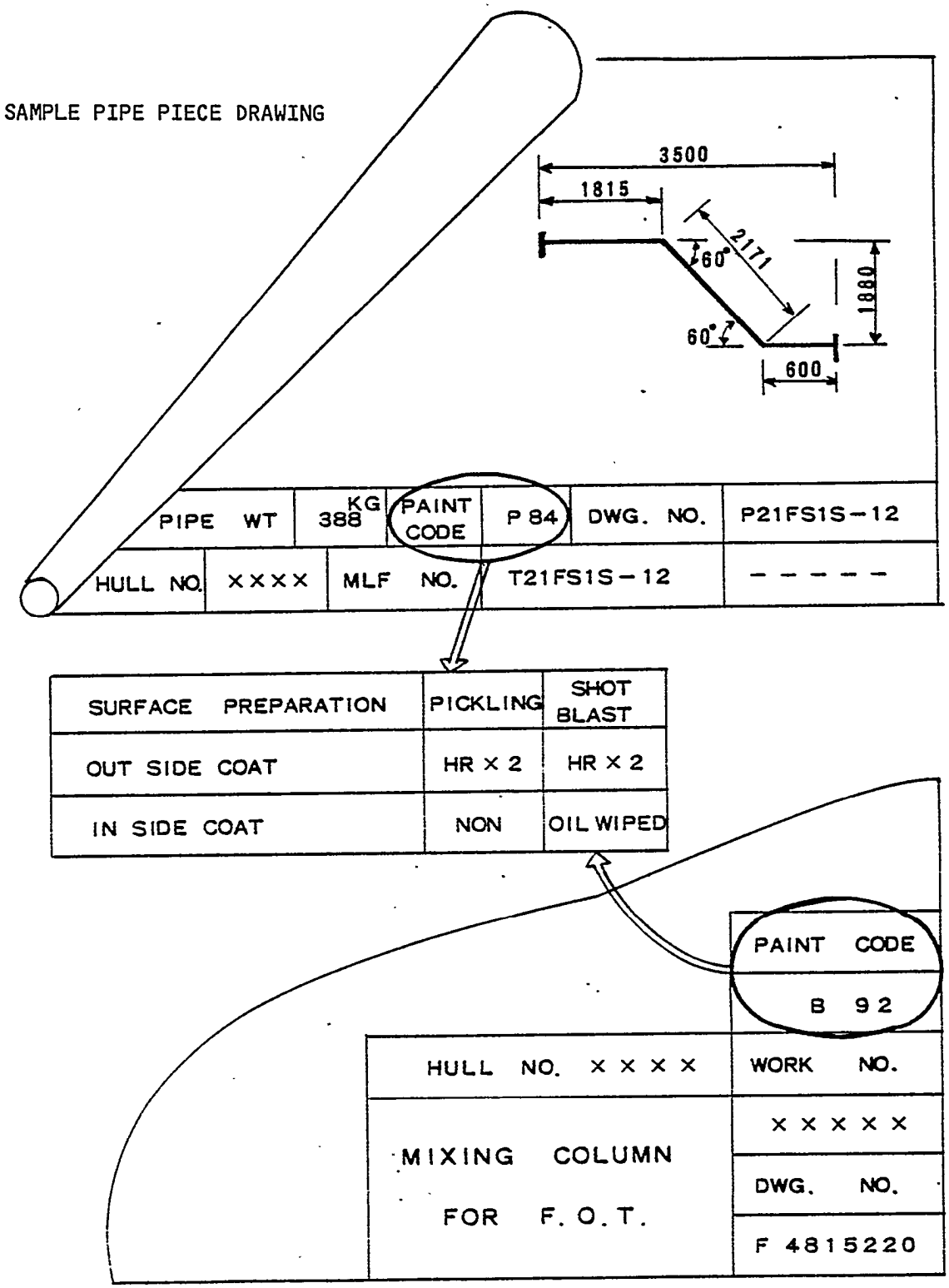


Figure 3-26 : Outfitting Components Detailed Drawings (with Paint Coding)

who are not familiar with painting to easily define the paint requirements on the outfit component detailed drawings. The painting requirements are easily found by referencing component paint specifications and the paint code system book. A sample paint code system is shown in Figure 3-27, and a coding system is established and standardized individually by each shipyard.

Outfit components such as the rader mast and derrick post are generally coated (except for the final coat) in-house or by subcontractor. These component assembly or piece drawings must indicate paint manufacturer, paint type, color, and number of coats.

The on-board paint work is specified by zones, as shown in Figures 3-20 and 3-21.

The paint planning has been described as. a step-by-step process, but once systems become standardized and the logic and principles are fully understood, some planning steps may be omitted by transferring planning duties to other groups or integrating them into a single planning section. For example:

- Transition drawings may be omitted and the on-block work instruction drawings and the on-board work instruction drawings may be developed directly,
- Material lists (MLS, MLF) may be omitted and replaced by the on-block/on-board paint work table,
- The pallet lists may be replaced by the on-block/on-board work instruction drawings, and
- The paint master plan and paint master schedule may be integrated into a single document.

A shipyard may omit or integrate some areas of planning depending on the shipyard situation.

PAINT SPEC. / SURFACE PREPARATION		0	1	2	3	4	5	...	...	26	27	28	29	30	...
	OUTSIDE	NON	WP	ZP	IZP	LZ×2	LZ×2 FC×1	...	...	ZP	ZP	ZP	ZP	ZP	...
	INSIDE	NON	WP	ZP	IZP	LZ×2	LZ×2 FC×1	...	...	WP	LZ×2	LZ×2 FC×2	TE	TE×2	...
SHOT BLAST	A		A 01	A 02	A 03	A 04	A 05	...	...	A 26	A 27	A 28	A 29	A 30	...
SAND BLAST	R		S 01	S 02	S 03	S 04	S 05	...	...	S 26	S 27	S 28	S 29	S 30	...
PICKLING	P		P 01	P 02	P 03	P 04	P 05	...	...	P 26	P 27	P 28	P 29	P 30	...
DISC SANDER/OR WIRE BRUSH	D		D 01	D 02	D 03	D 04	D 05	...	...	D 26	D 27	D 28	D 29	D	
POWER BRUSH	H		H 01	H 02	H 03	H 04	H 05	...	...	H 26	H 27	H 28			
⋮															

FC = Finish Paint
IZP = Inorganic Zinc Primer
LZ = Lead Zinc Chromate Prime
TE = Tar Epoxy Paint
WP = Wash Primer
ZP = Zinc Epoxy Primer

FOR EXAMPLE:

A 28 →
- SURFACE PREP. – SHOT BLAST
- OUTSIDE – ZINC EPOXY SHOP PRIMER
- INSIDE – LEAD ZINC CHROMATE PRIMER × 2
- INSIDE – FINISH PAINT × 2

Figure 3-27 : Paint Code System

3.4 FEED-BACK SYSTEM

After painting is completed, all data for man-hours spent and material used must be accumulated and documented. Then the actual. figures computed are compared with the estimated figures at each planning phase and the tables used for estimating are updated to include this data for future projects. For example, the paint area calculated by key plans and detailed plans must be fed back to the Basic Design Department and that figure must be added to the estimation charts such as in Figures 3-8 through 3-11. This provides statistical data from which the chart of required paint volume, as shown in Figure 3-7, is modified to become more accurate.

If any defects in the quality of the coating during construction or after delivery is reported, a failure analysis is performed. and the responsible organization is informed. Such defects are:

- Pin holes in the paint.
- Lack of adhesion between. paint and substrate.
- Sags or runs.
- Lack of adherence between *coats.*

Any discrepancies between the actual material used and estimated materials must be explained and resolved. These differences may be caused by workmanship; i.e. excessive re-work or the application of too much paint and if this is the case, the Painting Departmen is informed and they modify application methods and work practices. This measurement, productivity assessment and feed back completes the cycle. This completed loop is necessary for productivity improvement.

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